THERAPY OF PARENCHYMAL BRAIN CYSTICERCOSIS WITH PRAZIQUANTEL

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Abstract Twenty-six patients with cysticercosis of the brain parenchyma were treated with the antihelmintic agent praziquantel (50 mg per kilogram of body weight daily for 15 days). During treatment a strong inflammatory reaction occurred, as evidenced by increased protein and cells in the cerebrospinal fluid. This finding correlated with headache, exacerbation of neurologic symptoms, and edema and inflammation around cystic lesions.

After three months of treatment all patients had improved clinically, and 13 (50 per cent) were asymptomatic. The total number of cysts on CT scans had decreased from 152 at the beginning of treatment to 51, and the mean diameter of cysts was reduced by 72 per cent. CT scans showed improvement in 25 of the 26 patients, with total remission of all cysts in nine. Seventeen control patients followed with CT studies for a mean of 9±2 months had no spontaneous remission of lesions, and in many cases the scans showed worsening during the observation period.

Our results indicate that praziquantel is effective in cysticercosis of the brain parenchyma. (N Engl J Med 1984; 310:1001-7.)

CYSTICERCOSIS is the most common parasitosis affecting the central nervous system, and it is endemic in many developing countries.[1] Massive immigration from endemic areas is making neurocysticercosis a common disease in countries that were previously free of it.[2-4] The disorder produces a complex neurologic picture with many degrees of severity, depending on topography and the number of lesions. Parasites can be located in the brain parenchyma, subarachnoid space, or ventricular system in a highly variable number of combinations.[5] Secondary to the parasitic infestation is an inflammatory reaction that produces additional complications and in many instances causes more neurologic disturbances than does the parasite itself. Thus, neurocysticercosis is a disease composed of several syndromes.[6]

Until recently the only therapeutic approaches in this disease were steroid treatment and in some cases surgical removal of large cysts or use of a ventriculoatrial shunt for relief of hydrocephalus. In 1978 Chavarría and González[7] reported a successful treament of porcine cysticercosis with a pyrazinoisoquinoline — 2-(cyclohexylcarbonyl)-1,2,3,6,7,11b-hexahydro-4*H*-pyrazinol [2,1-*a*]isoquinolin-4-one — which is now known as praziquantel[8,9] and is an antihelmintic with activity against all known species of schistosomas.[10,11] In 1980 Robles and Chavarría obtained a beneficial response in a patient with neurocysticercosis treated with praziquantel.[12] Later, this finding was confirmed by other reports.[13-17]

However, most of these studies included a variety of forms of neurocysticercosis, such as those characterized by parenchymal calcifications, cysts, hydrocephalus and intracranial hypertension, and for that reason subjective evaluation of the response was the rule. In some cases simultaneous administration of steroids at the time of treatment made the results difficult to assess, since the relief of symptoms obtained with steroids in neurocysticercosis is due to their antiinflammatory action and is transient. Clinical evaluation alone for a supposed anticysticercus drug is not wholly reliable in patients with neurocysticercosis, since some common signs and symptoms may remain or follow an unpredictable course even after the destruction of parasites. In the case of hydrocephalus secondary to basal arachnoiditis, the obstruction of cerebrospinal-fluid circulation is due to fibrosis and inflammatory exudates within the subarachnoid space; thus, it is unlikely that the cerebrospinal-fluid transit would be free after the disappearance of cysticercus.

A high percentage of patients with neurocysticercosis have seizures, which theoretically could continue once the epileptic focus has been established; in addition, anticonvulsant therapy must not be suspended during the testing of anticysticercus drugs. Thus, the presence of epilepsy, a major sign of neurocysticercosis, cannot be taken as a reliable source of information about the therapeutic response. Another common symptom of neurocysticercosis is headache, whose follow-up is difficult and imprecise. The location of cysts

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is also important. Drug levels in blood are different from levels in ventricular or subarachnoid cerebrospinal fluid; consequently, the expected results would be different, depending on parenchymal, ventricular, or subarachnoid localization of parasites.

To investigate the possible role of praziquantel in the treatment of neurocysticercosis, we selected a group of patients with parenchymal macroscopic cysts demonstrated by computed tomography (CT), in whom an objective evaluation could be made after treatment. In this form of neurocysticercosis, though it is not the most frequent, it is possible to obtain direct evidence on the effects of the drug on the parasite.

Methods

Selection of Patients

Twenty-six patients were selected from a large group of patients with neurocysticercosis who were studied at the Instituto Nacional de Neurología y Neurocirugía de México. The following criteria were used: all patients selected had macroscopic cysts shown by simple and contrast CT scanning[18] (the number of cysts ranged from one large cyst to 38 (mean ±S.E., 5.8±1.2); all patients were in good general health, and their neurologic disease was stable; and all were free of intracranial hypertension. Patients who did not meet these criteria were excluded. The ages of the patients ranged from 18 to 53 years, with a mean of 35±7. The male/female ratio was 13/13; no children, elderly patients, or pregnant women were selected. The diagnosis of parenchymal cysticercosis was confirmed with the information obtained from clinical studies, an enzyme-linked immunosorbent assay for cysticercosis in blood, studies of cerebrospinal fluid, and CT scanning. However, the principal criterion for selection of patients was based on the CT image of large cysts that could be easily followed in subsequent studies. Patients in whom contrast CT scanning showed parenchymal cysts surrounded by edema and an intense concentration of contrast medium around lesions were not chosen for the trial, since we have observed that in some patients the cyst is spontaneously replaced by inflammatory tissue within a few months.[19]

All selected patients (Table 1) had large cysts with little or no tomographic evidence of inflammation around lesions; therefore, spontaneous remission of cysts was not expected in the short term. Nine patients had negative results on the enzyme-linked immunosorbent assay for cysticercosis in serum; this was considered to reflect immune tolerance to the parasite, since the patients selected had no radiologic evidence of an inflammatory reaction to the cysts. Fifteen patients had negative tests for cysticercosis in the cerebrospinal fluid at the beginning of the trial. However, the presence of multiple cysts in brain parenchyma and the absence in Mexico of other disorders, such as echinococcal cysts, that could give a similar tomographic picture made the diagnosis of neurocysticercosis highly probable. In our experience many patients with parenchymal cysticercosis do not have alterations in the cerebrospinal fluid when cysts are not in contact with the subarachnoid space.

Table 1. Results of CT Scanning before and after Treatment with Praziquantel in 26 Patients with Neurocysticercosis.

Patient No.	Previous CT (Control Group A)			Day before Start of Treatment		Last Day of Treatment		
	No. before treatment	No. of cysts	Total diameter *	No. of cysts	Total diameter *	No. of cysts	Total diameter *	Reduction †
1	14	7	48.2	9	54.5	9	41.2	25%
2	—	—	—	4	22.4	4	17.6	22%
3	—	—	—	5	12.2	2	6.0	51%
4	—	—	—	3	24.5	3	21.5	22%
5	—	—	—	4	16.5	3	10.3	37%
6	—	—	—	17	95.2	17	61.7	35%
7	—	—	—	29	149.5	22	96.9	35%
8	—	—	—	2	9.0	2	5.9	35%
9	—	—	—	7	20.9	5	9.8	53%
10	11	1	11.5	1	13.0	1	13.0	0%
11	5	7	40.8	7	37.1	7	35.0	6%
12	14	3	10.9	4	20.4	3	11.3	45%
13	—	—	—	1	6.3	1	4.5	29%
14	1	2	12.8	2	12.8	2	11.8	8%
15	—	—	—	2	13.2	2	13.2	0%
16	7	14	53.8	13	66.5	11	52.8	21%
17	13	2	6.3	2	6.3	2	6.1	3%
18	—	—	—	2	15.7	2	12.4	21%
19	—	—	—	4	21.6	1	6.9	68%
20	—	—	—	12	53.4	9	38.6	18%
21	2	4	18.8	3	15.4	2	8.5	45%
22	5	5	17.3	5	19.6	3	9.3	53%
23	1	1	3.9	1	5.3	1	4.2	21%
24	2	2	20.4	2	20.4	2	14.7	28%
25	2	2	13.3	2	13.3	2	9.0	32%
26	—	—	—	9	31.5	1	4.0	87%
Total ‡	—	2	—	152	776.5	119	526.2	
	6.4±1.5	4.2±1.0	21.5±4.8	5.8±1.2	29.9±6.3	4.6±1.0	20.2±4.3	31%

*The sum of the diameters of cysts (in millimeters); to convert to actual size multiply by 3.26.

‡Plus–minus values are means ±S.E.

(Table continues on next page.)

Controls

Two groups of controls were studied: 12 patients (Group A) served as their own controls, since studies in these patients (CT scan and spinal-fluid examination) had been performed 1 to 14 months (mean, 6.4±1.5) before the praziquantel trial, with a total of 77 months of observation. In addition, five patients with multiple parenchymal cysts (control Group B) were chosen from the CT-scan archives of the neuroradiology department. Selection was made with the same radiologic criteria used for praziquantel treatment, and all patients in this group had been clinically followed for 7 to 27 months (mean, 13.6±3.4), with a total of 75 months of observation. These patients had only the initial CT scan without radiologic follow-up; therefore, the long-term evolution of cysts was not known at the time of selection. These control patients were recalled, and new CT scans were obtained.

Treatment and Follow-up

Informed consent was obtained from all patients before the trial. Praziquantel was administered at a daily dosage of 50 mg per kilogram of body weight, distributed in three doses during 15 days.[13] Steroids were not given at any time during or after treatment with praziquantel. Only drugs for relief of symptoms, such as anticonvulsants, analgesics, or antivertiginous agents, were prescribed as needed. The patients remained at the hospital during the treatment. Clinical examination was performed every day during treatment and every month afterward. CT scanning and studies of cerebrospinal fluid were performed on the day before the start of treatment, on the last day of treatment, and three months after the end of treatment. Although the trial was designed to have a follow-up period of three months, at the time of data analysis, 12 patients had been studied for up to six months after the end of treatment. Neurologic status was recorded for each patient, and a subjective, individualized clinical score ranging from 0 (asymptomatic) to 4+ was assigned according to the severity of signs and symptoms. Twenty-four patients had epilepsy, 12 had chronic headache, 3 had psychiatric disturbances, one had hemiparesis, one had chorea, and one had chronic vertigo. All patients were clinically observed by the same neurologist. Cerebrospinal fluid was obtained by lumbar puncture and analyzed for cell and protein content; complement-fixation tests for cysticercosis[20] and enzyme-linked immunosorbent assays for the disease were performed before and after treatment.

Simple and contrast CT scanning was performed with an EMI 1005-unit scanner with a 160-by-160 matrix.[18] Macroscopic cysts were counted for every patient; the same cyst appearing on different CT slices was counted only once. The maximum diameter of each cyst was measured on the CT image with a micrometric scale with an accuracy of 0.1 mm. The sum of the diameters of cysts in each patient was plotted at each evaluation (Table 1). Measurements were made directly on the CT image, which represents 32 per cent of actual size. Summing of diameters of cysts was done with the results obtained directly on the CT photography, without arithmetic conversion to real size. Evaluation was made at the end of the trial, with all radiologic material. Since evaluation of CT is objective it was not blind. However, it was made independently by two groups of clinicians and radiologists, whose findings were the same.

Table 1 (continued).

3 Mo. after Treatment			6 Mo. after Treatment		
No. of cysts	Total diameter *	Reduction †	No. of cysts	Total diameter *	Reduction †
0	0	100%	—	—	—
2	9.5	58%	1	4.5	80%
0	0	100%	0	0	100%
1	6.0	76%	0	0	100%
3	8.5	49%	—	—	—
12	34.1	64%	6	13.1	86%
6	32.9	78%	—	—	—
0	0	100%	—	—	—
0	0	100%	—	—	—
1	13.0	0%	—	—	—
5	24.5	34%	5	22.7	39%
2	5.6	73%	1	2.2	89%
1	1.8	72%	0	0	100%
1	4.0	69%	0	0	100%
2	5.1	61%	—	—	—
7	33.4	48%	6	18.1	73%
0	0	100%	0	0	100%
1	4.9	69%	—	—	—
0	0	100%	—	—	—
4	14.8	72%	4	12.1	77%
1	2.9	81%	—	—	—
0	0	100%	—	—	—
1	3.0	43%	0	0	100%
1	11.0	46%	—	—	—
0	0	100%	—	—	—
0	0	100%	—	—	—
51	215		—	—	
2.0±0.5	8.3±2.1	73%	1.9±0.7	6±2.3	80%

†Percentage reduction in the diameter of cysts in relation to the diameter at the beginning of treatment.

Results

Control Groups

The 12 patients in Group A had had previous studies (mean follow-up, 6.4±1.5 months). The last CT scan showed that in 4 of these 12 (Patients 14, 17, 24, and 25) the cysts had remained unchanged in the period between the initial studies and the beginning of the trial. In six (Patients 1, 10, 11, 12, 22, and 23) either the cysts had grown or new ones had appeared (or both). In each of the remaining two (Patients 16 and 21), who originally had 14 and 4 cysts, respectively, one cyst had disappeared but the remaining cysts had increased in size.

In the other five control patients (Group B, Table 2) no spontaneous remission of parenchymal cysticercosis was seen (Fig. 1). Two patients had new cysts (not detected in previous CT scans), and in all five patients the last CT scan demonstrated enlargement of cysts after a mean of 15±3.8 months of follow-up (Table 2). When Groups A and B were considered as a whole (17 patients) the CT scan demonstrated a 12 per cent increase in the total number of cysts and a 14 per cent increase in the size of cysts during a mean interval of 9±2 months. The cerebrospinal fluid and the clinical status in these patients showed considerable variation, with exacerbations and partial remissions related to periods of steroid therapy.

Patients Treated with Praziquantel

During treatment 24 patients (92 per cent) had exacerbations of neurologic symptoms or adverse reactions, mostly severe headache (92 per cent). Twelve patients with epilepsy had seizures during treatment. In two patients an intracranial hypertension syn-

Table 2. Results of CT-Scanning in Follow-up of Five Control Patients (Group B) with Parenchymal Neurocysticercosis.

Patient No.	Initial Scan		Interval (Mo.)	Last Scan		Increase in Total Diameter *
	No. of cysts	Total diameter		No. of cysts	Total diameter	
1	16	35.5	21	19	46.3	30%
2	32	152.0	11	41	171.5	13%
3	4	17.7	9	4	22.1	25%
4	3	21.4	7	3	26.7	25%
5	2	6.7	27	2	8.5	27%
Total †	57	233.3	75	69	275.1	18%
	11.4±5.7	46.6±26.7	15±3.8	13.8±74	55±29.7	

*"Total diameter" refers to the sum of the diameters of cysts (in millimeters); to convert to actual size multiply by 3.26.

†Plus–minus values are means ±S.E.

drome developed that did not require steroids or special measures. Other reactions included hyperthermia and vomiting; one patient had gastritis. All secondary effects abated soon after the end of treatment. Three months after the end of treatment, neurologic symptoms and signs had improved in nearly all patients, and 13 (50 per cent) were asymptomatic. After six months of observation 7 of 12 evaluated patients (58 per cent) were asymptomatic.

The cerebrospinal fluid showed dramatic changes with an inflammatory reaction during treatment in many patients. Nine of 25 evaluated patients (36 per cent) who had had normal levels of proteins (below 40 mg per deciliter) on the day before starting praziquantel had a severe increase in proteins in cerebrospinal fluid obtained on the last day of treatment. A similar observation was made in the cell count; in 11 patients who initially had less than five cells per cubic millimeter, mononuclear pleocytosis developed. These alterations had remitted in most patients when cerebrospinal fluid was examined three months after treatment. The mean value for protein (in milligrams per deciliter) was 37±6 on the day before the start of treatment, 52±5 on the last day of treatment, 40±3 three months after treatment, and 38±4 six months after treatment. The mean value for cells (per cubic millimeter) was 11±3 on the day before the start of treatment, 78±22 on the last day of treatment, 25±10 three months after treatment, and 8±7 six months after treatment. The complement-fixation test for cysticercosis in cerebrospinal fluid was positive on the last day of treatment in six patients who had previously had negative tests. The intensity of the complement-fixation reaction increased with high dilutions in most positive spinal fluid obtained on the last day of treatment. The enzyme-linked immunosorbent assay for cysticercosis in serum became positive in four patients who had previously had negative tests (data not shown).

CT scans on the last day of treatment demonstrated a concentration of contrast medium around the cysts in many patients (Fig. 2 and 3). This feature had not been observed in previous CT scans (see Selection of Patients). At this time 33 cysts from the original 152 had disappeared (22 per cent), and the diameter of cysts in all treated patients combined had diminished from 776.5 to 526.2 mm — a reduction of 31 per cent (Table 1). Three months after treatment CT showed that 101 cysts from the original 152 had disappeared (66 per cent), and the total diameter of all cysts had diminished from 776.5 to 215 mm — a reduction of 72 per cent. In 12 patients evaluated six months after treatment, CT scans showed that 67 per cent of the original cysts had disappeared with total remission,

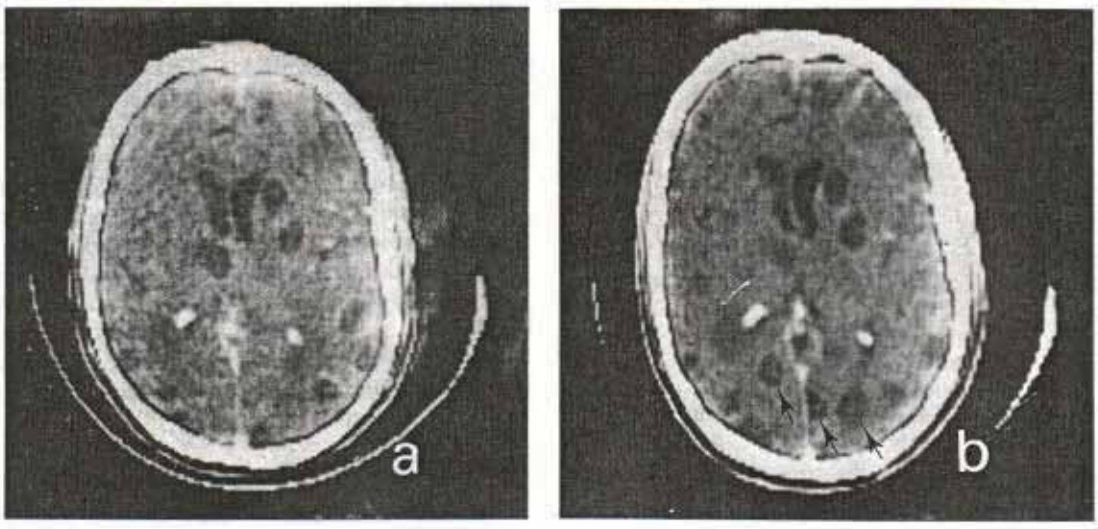

Figure 1. Follow-up Contrast CT Scans of a Control Patient with Multiple Parenchymal Cysts (Patient 2, Table 2), Showing the Natural Evolution of this Form of Neurocysticercosis.

Part a shows 11 large cysts in the brain parenchyma. Part b, a scan taken after 11 months, demonstrates at least three new cysts (arrows) and enlargement of many of the cysts seen in the first scan.

and the total diameter of cysts had diminished by 80 per cent. Most cystic lesions that showed remission were not replaced by inflammatory tissue (Fig. 3); however, occasionally a small area of inflammation in place of the original cyst was observed in subsequent studies.

CT studies of the individual response to praziquantel treatment after three months of follow-up indicated that total remission of all cysts was achieved in 9 of 26 patients (35 per cent) and a partial reduction in the size of cysts was achieved in 16 of 26 patients (61 per cent), of whom 11 had more than a 50 per cent reduction and 5 had less. One patient had no changes on the CT scan after three months of follow-up (Patient 10, Table 1).

Discussion

Our results indicate that praziquantel is an effective drug ($P<0.008$ by Student's t-test) for the treatment of cysticercosis of the brain parenchyma. Improvement on the CT image was observed in 96 per cent of patients, with a high percentage of total remission of all cystic lesions demonstrated by CT scanning (35 per cent). Follow-up scans of control patients showed that this form of neurocysticercosis worsens in most cases without spontaneous remission.

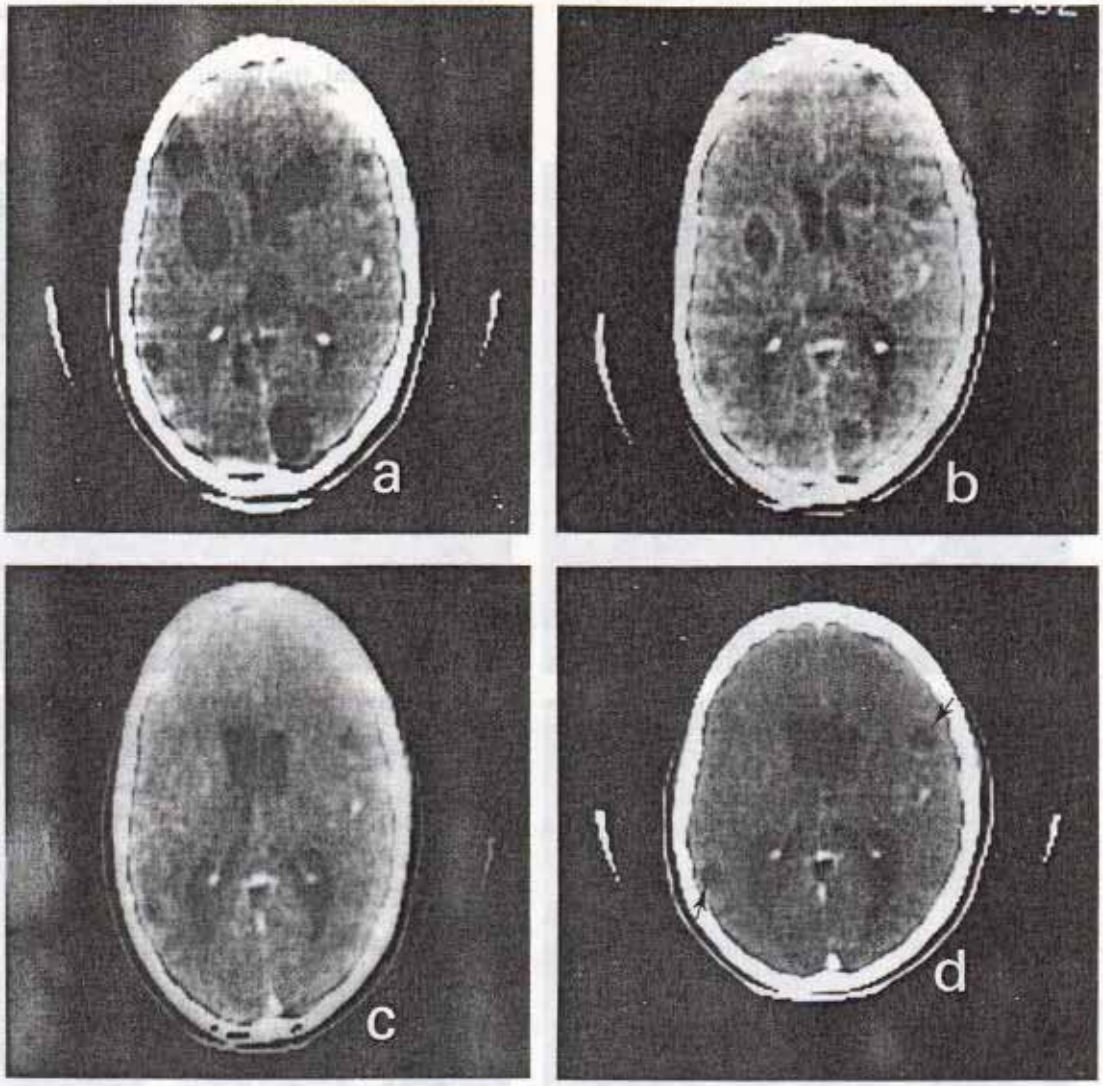

Figure 2. Contrast CT Scans before and after Praziquantel Therapy in a Patient with Macroscopic Cysticercus (Patient 7, Table 1).

Part a shows a scan taken before treatment, in which 12 cysts were found. Part b shows the same slice in the CT taken on the last day of treatment; note the intense concentration of contrast medium around the lesions. Part c shows that after three months, most of the cysts disappeared. In Part d, a scan obtained six months after treatment, only two cysts remain (arrows), with total resolution of most of the lesions found before treatment. However, the ventricles show enlargement due to residual fibrosis in the subarachnoid space.

Long-term observation of patients with partial remission will define the evolution of cysts affected initially by praziquantel. On the basis of our data a second treatment with praziquantel three months after the first might be recommended in patients with partial resolution of cysts. However, we do not know whether improvement can be further increased with subsequent treatments. Whether praziquantel has a role in the treatment of other forms of neurocysticercosis, such as arachnoiditis (the most common), multiple miliary cysts with brain edema, intraventricular cysts, and spinal cysticercosis, remains to be studied. The changes in the cerebrospinal fluid of patients in this study suggest that the effect of praziquantel is extended to the subarachnoid space, although its precise therapeutic value in arachnoiditis is yet to be determined.

Administration of praziquantel in healthy volunteers does not produce adverse reactions in the central nervous system.[21] Pharmacologic studies have not shown toxicity at doses of 50 mg per kilogram and have suggested that the drug is safe.[22,23] If so, the secondary reactions occurring during treatment with praziquantel in patients with neurocysticercosis may be due to changes in the parasite that are induced by the drug and that lead to a strong inflammatory reaction in the host. This reaction must be considered a possible source of risk in some cases; although our patients did not have serious complications, they were selected patients without intracranial hypertension and were in good general health. Whether to administer both praziquantel and steroids must be decided on an individual basis, particularly in patients with intracranial hypertension or an uncertain neurologic condition.[24]

The medical treatment of neurocysticercosis is

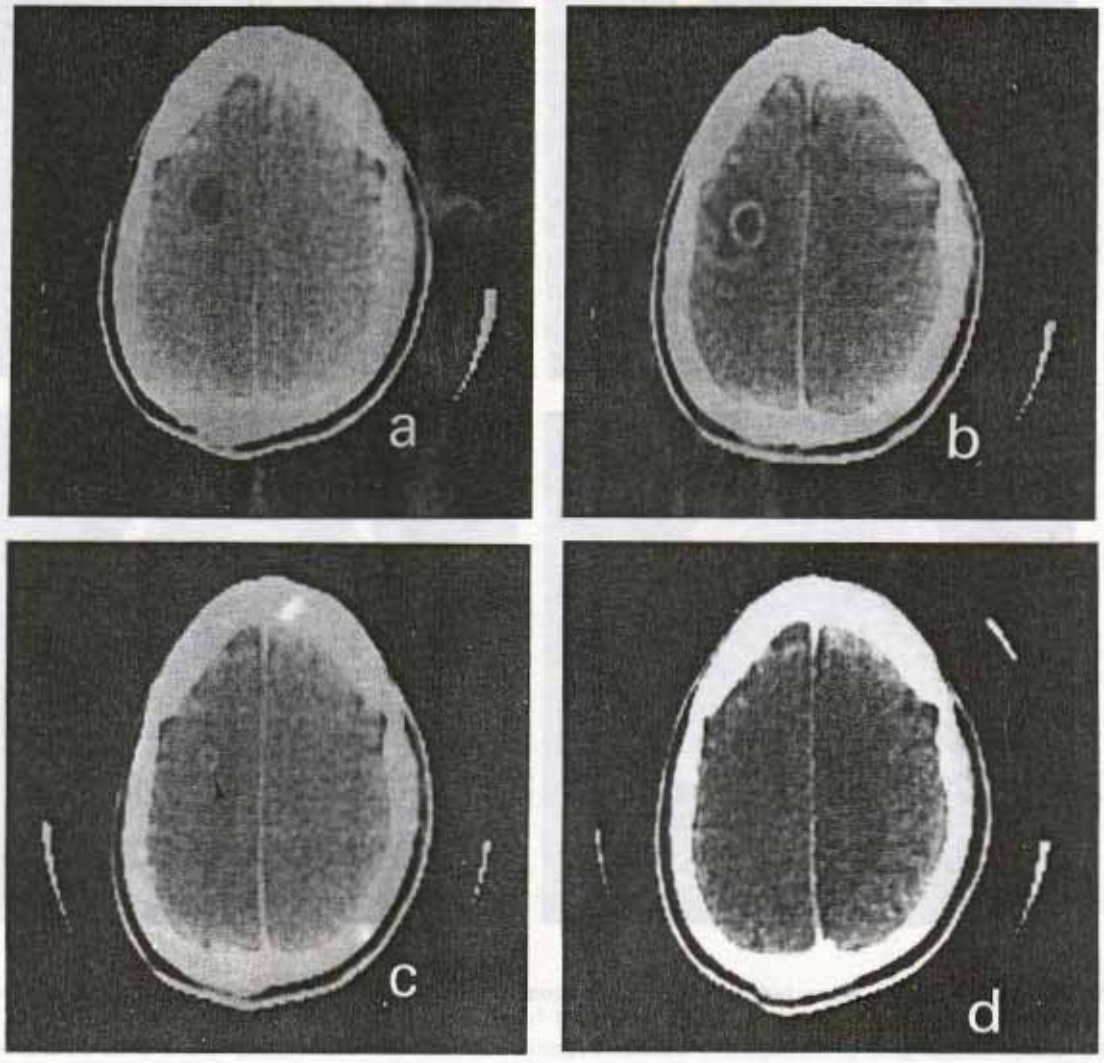

Figure 3. CT Scans Showing the Evolution of Cysticercosis in Patient 13 (Table 1) after Treatment.

Part a shows a contrast CT taken before treatment; a large frontal cyst was demonstrated. Part b, a scan obtained on the last day of treatment, shows evidence of inflammation around the cyst. Three months later (Part c) the cyst was notably reduced in size and was still surrounded by inflammation (arrow). Six months after treatment (Part d) the scan was normal. Note that the lesion was not replaced by an inflammatory tissue response.

greatly improved by praziquantel, the first effective drug against cysticercus. Since praziquantel is also active against the adult worm *Taenia solium*,[23] it offers a possiblity for the therapeutic control of the disease by acting on different forms in the life cycle of the parasite.[25] However, it should be stressed that in many cases cysticercosis of the central nervous system produces neurologic sequelae, such as granulomas, calcifications, basal fibrosis, and hydrocephalus (Fig. 2), that require additional treatments.[26] Therefore, the best action against cysticercosis lies in preventive medicine rather than in therapeutic measures.

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