Denouement and Comment

Neurocysticercosis

The 1-cm focal hypodensity in the left frontal lobe with rim enhancement and associated zone of vasogenic edema shown in Figure 1 and the left frontal cystic lesion with a thick rim of surrounding enhancement and surrounding vasogenic edema shown in Figure 2 are characteristic of a degenerating parenchymal cysticercus; Figure 2 also shows a punctate area of central high signal, likely representing the scolex of a parasite. Neurocysticercosis is the most common parasitic disease of the central nervous system and the leading cause of acquired epilepsy worldwide.[1] The causative pathogen, *Taenia solium*, is harbored by an estimated 20 million people, most of whom live in Mexico, Latin America, sub-Saharan Africa, India, and Southeast Asia. Though most prevalent in these areas, increased rates of travel and immigration have made neurocysticercosis more common in developed nations. It is an emerging infectious disease in the United States, where approximately 1000 new cases are diagnosed each year.[2] Infection can occur at any age, but the clinical manifestations peak in the third and fourth decade of life. Ten percent of patients are children.[3]

PATHOGENESIS

The life cycle of *T solium* revolves around its 2 developmental forms: the adult segmented worm causes taeniasis, an intestinal tapeworm infection, while the larval stage causes cysticercosis, an invasive form of infection. Pigs ingest *T solium* eggs. However, humans are the only host of both forms of the parasite, and pigs serve only as intermediates by harboring the cysticerci. In the intestine, the eggs release embryos, which penetrate the intestinal mucosa, enter the bloodstream, and burrow into tissues where they mature into cysticerci (infective larvae). Humans, as the definitive host, ingest the cysticerci in undercooked pork. The cysticerci mature into adult worms in the small intestine, where they attach and produce eggs (taeniasis) to continue the parasite life cycle. Cysticercosis occurs when humans act as the intermediate host. In such instances, humans ingest *T solium* eggs through fecal-oral contact with humans with taeniasis. The eggs hatch in the human intestine, liberating embryos that then penetrate the intestinal mucosa and disseminate to various organs (eg, brain, eye, muscle) via the bloodstream. The clinical manifestations of cysticercosis reflect the location of these cysticerci.

Central nervous system disease (neurocysticercosis) is influenced by the parasite load, location, and the patient's immune status. In most cases, neurocysticercosis in children manifests as a single cystic parenchymal brain lesion (multiple cysts are more common in adults) that is either clinically silent and self-resolving or characterized by partial seizures with or without secondary generalization. Though rare in children, extraparenchymal disease can cause hydrocephalus or encephalitis with headaches, mental status changes, and even life-threatening intracranial pressures. Spinal cord involvement is extremely rare at any age.[2,4]

DIAGNOSIS

Accurate diagnosis of neurocysticercosis requires clinical and epidemiologic data to direct radiological imaging and serologic testing. Proposed diagnostic criteria are complex[5] and yet to be validated and, therefore, are not universally accepted. The only absolute criteria—biopsy specimen of a brain lesion, direct visualization of parasites by funduscopic examination, or scolex identification on CT or MRI—are rarely met. However, within the right context, CT and MRI are quite helpful. Initially, the cysticercus appears as a hypodense, fluid-filled cystic structure without surrounding inflammation or edema; the patient is usually clinically asymptomatic at this stage. Invocation of the host immune response results in parasite degeneration creating annular enhancement around the cyst (Figure 1), increasing fluid density within, and surrounding edema (Figure 2). Seizures are a common manifestation during this stage. This intermediate stage is followed by granulomatous change and, ultimately, calcification and occasionally disappearance. Computed tomography best visualizes granulomas and calcifications, while MRI (T2-weighted or gadolinium-enhanced) better defines surrounding edema (immune response) and fluid content (viability) and is superior for extraparenchymal disease. Many serologic assays are fraught with error related to poor specificity and to the high rate of seropositivity in endemic areas among those exposed but without active central nervous system disease. Enzyme-linked immunotransfer blot has a specificity approaching 100%, but the sensitivity is less than 50% in patients with solitary cystic lesions. Inflammatory changes in cerebrospinal fluid are nonspecific and only present in extraparenchymal disease. An ophthalmologic examination should always be performed to exclude eye disease, which alters treatment.

TREATMENT

Although safe and effective drugs are readily available, antiparasitic treatment of neurocysticercosis is controversial. Both praziquantel and albendazole are appropriate, though albendazole (15 mg/kg per day for 28 days) is favored as the first-line agent secondary to its lower price, increased cysticidal activity, increased plasma levels during concomitant corticosteroid therapy (by contrast, corticosteroid therapy leads to lower praziquantel levels), and minimal toxic effects. Steroids are recommended as coagents to reduce the inflammation triggered by parasite destruction. Appropriate antiepileptic therapy should also be used in conjunction with these drugs. The theoretical argument against treatment lies in the belief that the inflammatory immune response to the parasite—not the mass effect of the parasite—triggers seizure activity. Thus, if a viable cyst resides in

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Table. Comparison of Randomized Controlled Trials of Albendazole Compared With Placebo for Small, Enhancing Parenchymal Brain Lesions by Computed Tomography in Children With New-Onset Focal Seizures

Source	Sample Size	No. of Lesions	Lesion Resolution Compared With Placebo	Seizure Frequency Compared With Placebo
Baranwal et al,[8] 1998	63	1	Increased	No significant difference
Kalra et al,[9] 2003	123	1-2	Increased	Decreased
Gogia et al,[10] 2003	72	1-2*	No significant difference	No significant difference
Singhi et al,[7] 2004	133	1	No significant difference	Decreased

*Sixteen percent of patients in this study had more than 2 lesions. Seventy percent of the patients had solitary lesions.

the brain evading a significant immune response, it might be detrimental to induce parasite destruction and subsequent inflammation. Also, the cysts and seizures often spontaneously resolve without specific therapy.[6] Some data support this stance, but most studies were not randomized and include patients of varying ages, different numbers and locations of cysts, and a multitude of outcomes. Four randomized controlled trials[7-10] have been conducted in children with 1 or 2 parenchymal cysts and new-onset partial seizures (**Table**). The results are mixed; 2 of the 4 albendazole treatment groups displayed better lesion resolution and improved seizure control, while the other 2 were not statistically different. The high rate of spontaneous resolution of both radiographic and clinical manifestations of this common manifestation of neurocysticercosis may require larger patient groups and meta-analyses to definitively show statistical significance higher than the apparent trend gleaned from these few pediatric studies.

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