Headaches and seizures

WILLIAM J. BUFKIN, MD

A 20-year-old Hispanic man presented to the emergency department because of the recent onset of headaches and seizures. He had no history of a previous illness. The patient had

moved to Texas from Mexico approximately 2 years earlier. Imaging studies are shown below (Figures 1–4).

For diagnosis and discussion, see the following page.

Figure 1. Axial fluid-attenuated inversion recovery magnetic resonance (MR) image shows a low-signal-intensity mass (arrowhead) in the left frontal lobe that contains a high-signal-intensity nodule (arrow).

Figure 2. Gadolinium-enhanced axial T1-weighted MR image demonstrates a ring-enhancing mass (arrows) in the posterior aspect of the left temporal lobe.

Figure 3. Unenhanced axial computed tomography (CT) image demonstrates a small calcified nodule (arrow) at the corticomedullary junction in the right frontal lobe.

Figure 4. Axial T2-weighted MR image shows a cystic mass in the posterior aspect of the left temporal lobe (arrowheads) that is surrounded by edema (arrows).

From the Department of Radiology, Baylor University Medical Center, Dallas, Texas.

Corresponding author: William J. Bufkin, MD, Department of Radiology, Baylor University Medical Center, 3500 Gaston Avenue, Dallas, Texas 75246.

DIAGNOSIS: Neurocysticercosis.

DISCUSSION

Cysticercosis is a parasitic infection produced by *Taenia solium* larvae (cysticerci). When cysticerci are located in the central nervous system, the disease is known as neurocysticercosis (NCC).

Epidemiology

NCC is the most common and widely disseminated human neuroparasitosis. The disease is endemic in most countries of Latin America, Central and South Africa, and Asia and is frequently encountered in Portugal, Spain, and the Eastern European countries. In recent years, the disease has been increasing in frequency. Beginning in the mid-1970s, the number of reported cases in the southwestern USA increased dramatically, corresponding to the increase in the number of Hispanic immigrants from Latin America. Fecal contamination of the hands is one of the common forms of egg transmission; thus, the disease is usually present in areas where hygiene is poor. The use of contaminated water for irrigation of vegetables, consumption of pork infested with cysticerci, and direct personal contact with *T. solium* carriers are other important factors contributing to high prevalence rates of cysticercosis and NCC. Autopsy reports from general hospitals in several countries of Latin America, Africa, and Asia report an incidence of NCC from 0.1% to 3.6%. It is probable, however, that the incidence of NCC has been underestimated because few professionals with adequate skills in neuropathology are available in the areas where NCC is endemic (1).

Modes of transmission

T. solium, the pork tapeworm, has a complex life cycle. Pigs are the primary intermediate host, and humans can be either the definitive host (infected with the tapeworm) or an intermediate host (infected with the cysticercus) (2, 3). Humans are the only definitive host for *T. solium*. The adult tapeworm lives in the small intestine of humans and attaches itself to the intestinal mucosa by a larval head (scolex) that has 4 lateral suckers and a terminal rostellum containing 25 to 50 hooklets (1). Infection with the parasite usually does not produce symptoms (3). *T. solium* is a hermaphrodite, and the gravid proglottids are released into the intestinal lumen. Approximately 4 to 5 proglottids break off from the adult worm each day and enter the environment by discharge in the feces. Each proglottid contains 60,000 to 75,000 eggs. The eggs can then be ingested by pigs, humans, or other mammals. The pig is the most common intermediate host because it is coprophagic. Upon entering the digestive tract, the eggs produce embryos, or oncospheres, that enter the systemic circulation and are transported to the definitive organ (e.g., skeletal muscle, eye, central nervous system, subcutaneous tissue) of the host. Approximately 2 months after entering the circulation, oncospheres develop into cysticerci. The life cycle is completed when humans eat undercooked pork infested with viable cysticerci, and a cysticercus enters the small intestine and develops into an adult tapeworm.

There are 3 fecal-oral routes by which humans can ingest the mature *T. solium* eggs and consequentially become the intermediate host. The most common route is by heteroinfection, in which the eggs are ingested in food contaminated by the feces

of *T. solium* carriers. Another route of infection, exogenous autoinfection, occurs when a carrier of the adult *T. solium* tapeworm ingests food contaminated by eggs produced by a tapeworm present in his or her own small intestine. This route is believed to be uncommon because patients infrequently have both cysticercosis and taeniasis. The third route of infection, endogenous autoinfection, occurs when eggs of the adult tapeworm return to the stomach by reverse peristalsis. This route of infection, however, is highly questionable because the mature proglottids are located in the third portion of the small intestine.

Larval morphology

Until the second half of the 19th century, the larval form of the parasite was believed to be a distinct species and was referred to as *Cysticercus cellulosae*. This designation has persisted despite the demonstration of the life cycle of *T. solium*. The *C. cellulosae* larva is characterized by a rounded or oval cyst 5 to 15 mm in diameter that contains an invaginated scolex (1, 2). A second larval variety, *C. racemosus*, exists but is less common than *C. cellulosae*. The *C. racemosus* larval cysts are 4 to 12 mm in diameter and are frequently found as multiple unequal-sized cysts that resemble a cluster of grapes. Figures 5 and 6 illustrate the racemose form of the disease, in which the scolex is absent. *C. cellulosae* segmentation and/or sprouting of new cysts produces the racemose form with gradual expansion of the cyst and degeneration of the scolex. The racemose and intermediate forms occur only in humans. The 2 larval forms coexist in approximately 10% of cases of human NCC.

The number of parasites in NCC varies widely. Solitary cysticerci are present in 20% to 53% of cases, and when cysticerci are multiple they are usually few (1). The 4 recognized patterns of the disease are parenchymal, subarachnoid, intraventricular, and mixed. The parenchymal type is believed to be the most common (3).

The cysticerci may be located in any part of the brain, leptomeninges, or spinal cord; however, the preferred locations depend on the larval variety. The subarachnoid spaces of the cerebral convexity are the preferred site for *C. cellulosae*, followed by the brain parenchyma and ventricular cavities. The usual location in the brain parenchyma is the cortex and in the junction between the gray and white matter. The preferred locations for *C. racemosus* are the basal cisterns, sylvian fissure, and ventricular cavities (1). The cysticercus is usually viable in the central nervous system for 2 to 6 years, and this period is usually determined by the host's immune tolerance (1, 3).

Symptoms

NCC can produce a variety of symptoms, and the combination of 2 or more symptoms is common. In endemic areas, NCC should always be considered in the differential diagnosis of neurological and neuropsychiatric diseases. The disease can also be asymptomatic. NCC can occur at any age but is more common in young and middle-aged adults. The disease is slightly more common in males.

The pathologic conditions that the disease produces in the brain, spinal cord, and leptomeninges are the result of the compressive and obstructive effects of the cysticerci combined with the local host immune-inflammatory response. The compressive

Figure 5. Axial T2-weighted MR image demonstrates numerous cysts (arrows) in the basal cisterns and adjacent to the cerebellar vermis. Photo: Greg Schucany, MD.

effects result from the mass produced by a large cysticercus or multiple small cysticerci. The obstructive effects result from blockage of the cerebrospinal fluid (CSF) circulation by cysticerci located in the ventricles or the subarachnoid space. Obstruction, however, is more often secondary to granular ependymitis (ventricular NCC) and fibrosing chronic leptomeningitis (subarachnoid NCC). The onset of symptoms associated with NCC is primarily secondary to the host immune-inflammatory response. The inflammatory reaction surrounding a cysticercus is usually minimal or absent. The parasite remains viable for many years; however, death of the cysticercus produces massive antigen exposure that intensifies the immune response/inflammatory reaction and initiates or exacerbates symptoms.

Classification of NCC

Classifications have been attempted based on anatomical features, clinical symptoms, disease activity as determined by imaging procedures and CSF analysis, and prognosis. However, because of the complexity of NCC, none of these classifications is entirely satisfactory.

A clinicopathological classification categorizes cases as follows: asymptomatic form, convulsive form, cysticercotic leptomeningitis, intraventricular cysticercosis, cerebrovascular cysticercosis, cysticercotic encephalitis, disseminated cysticercosis, demented form, spinal cysticercosis, and combined forms. Based on autopsy studies, the asymptomatic form is the most common form and corresponds to approximately 80% of cases. The convulsive form is the most common symptomatic form. In areas where NCC is endemic, the disease is one of the major causes of late-onset epilepsy, and in these patients viable, necrotic, or fibrocalcified cysticerci may be present. Death of the cysticercus is believed to be associated with an increased frequency of seizures, and clinical improvement correlates with involution of the cysticercus. Cysticercal leptomeningitis is the

Figure 6. Axial T2-weighted MR image shows numerous cysts (arrows) in the subarachnoid space surrounding the cerebellum. Photo: Greg Schucany, MD.

second most common cause of symptomatic NCC. Intraventricular cysticercosis usually consists of a solitary cyst of *C. cellulosae* in the fourth ventricle. Movement of the cyst within the ventricle may produce intermittent obstruction of the flow of CSF with transient episodes of increased intracranial pressure that may cause loss of consciousness.

Diagnosis

Because of the polymorphic symptomatology of the disease, clinical diagnosis of NCC is usually difficult. The diagnosis is probable when solitary or multiple lesions are shown by neuroimaging procedures and CSF immunological test results are positive. The clinical history and information about life conditions may be helpful in some cases. A definitive diagnosis depends on obtaining pathological tissue by autopsy or surgery.

The findings on CT and MR imaging depend on the type of cysticercosis, the stage of larval development and involution, and the number and location of the cysts. On CT and MR imaging, the viable *C. cellulosae* is a solitary lesion or multiple round, hypodense, nonenhancing lesions that are 5 to 10 mm in diameter and contain a scolex (as shown in Figure 1). When the cysticercus becomes necrotic, the lesion is surrounded by edema (as shown in Figure 4), usually in a ringlike pattern. In the nodular calcified stage, a calcified mass is present (as shown in Figure 3). In evaluating patients with NCC, MR imaging is superior to CT (1).

1. Pittella JE. Neurocysticercosis. *Brain Pathology* 1997;7:681–693.
2. Noujaim SE, Rossi MD, Rao SK, Cacciarelli AA, Mendonca RA, Wang AM, Coelho FH. CT and MR imaging of neurocysticercosis. *AJR Am J Roentgenol* 1999;173:1485–1490.
3. Hansman Whiteman ML, Bowen BC, Donovan Post MJ, Bell MD. Intracranial infection. In Atlas SW, ed. *Magnetic Resonance Imaging of the Brain and Spine*, 3rd ed, vol I. Philadelphia: Lippincott Williams & Wilkins, 2002:1158–1165.