Case 26

A 32-year-old female presents to the emergency room after having a generalized tonic-clonic seizure at home. Her CT scan is depicted below.

1. What is the differential diagnosis?

Although toxoplasmosis could also have this ring-enhancing appearance, it typically does not cause disease in immunocompetent patients. This imaging appearance is most consistent with neurocysticercosis (NCC), as there are multiple cysts in the brain at different larval stages of development. Multiple brain abscesses, cavernomas, and metastatic tumors must also be ruled out (Osborn, 1994, p 430, 642-645, 709-712)\textsuperscript{[113]}; (Psarros, et al., 2003, p 397-401)\textsuperscript{[125]}.

2. Describe the life cycle of the tapeworm, *Taenia solium*?

Humans are the definitive host for the adult tapeworm *Taenia solium*, which most often resides in the small intestine without consequence. Excretion of eggs in the feces usually leads to ingestion of eggs in contaminated water or food by an intermediate host, typically human or pig. Once inside the intestine, the eggs are released and develop into primary larvae, which cross the intestinal wall and enter the bloodstream. Hematogenous spread to muscular, ocular, and neural tissue then ensues. Once inside the brain, the primary larvae develop into secondary larvae, the cysticerci (Osborn, 1994, p 709-710)\textsuperscript{[113]}; (Psarros, et al., 2003, p 397-401)\textsuperscript{[125]}.

3. Describe the various larval stages of brain cysticercosis and their imaging characteristics?

In the brain parenchyma, the larva undergoes an orderly life cycle, from cysticercus to involution. These pathologic stages have specific imaging characteristics.

Stage I: Vesicular stage: The cysticercus generally consists of a thin capsule, a viable larvae, and a fluid filled bladder or sac. This phase of development is not normally imaged resulting from the lack of symptoms. If imaged, it appears as a cystic mass with mural nodule on both computed tomography (CT) and magnetic resonance imaging (MRI). The mural nodule generally represents the scolex. They are usually antigenically inert at this stage and do not tend to incite an inflammatory response accounting for the lack of edema on MR imaging.
Larval viability has been estimated to average 4 to 5 years.

Stage II: Colloidal stage: At this stage the parasite begins to die releasing metabolic products that incite a localized inflammatory response, cerebral edema, and breakdown of the blood-brain barrier. The capsule thickens resulting in ring enhancement. The fluid within the cyst transforms into a colloidal or more turbulent suspension consistent with protein solutes on T1-weighted imaging. The scolex and cyst capsule have decreased signal intensity on T2-weighted imaging. On CT, the cyst contents are more dense. Patient generally become symptomatic at this stage with the most common problem being seizures, headaches, and signs of raised intracranial pressure.

Stage III: Nodular granular stage: There is further degeneration of the cysticercus, the perilesional edema gradually diminishes, the cyst continues to involute, and the contents begin to mineralize. The lesion is now isointense with brain parenchyma on T1-weighted imaging and hypointense on T2-weighted imaging. On CT, the lesion is isodense and with thick nodular ring enhancement.

Stage IV: Calcified stage: In this stage there is complete involution of the lesion with continued mineralization. Calcification is most obvious on CT imaging (Osborn, 1994, p 710-712)\textsuperscript{113}; (Psarros, et al., 2003, p 397-401)\textsuperscript{125}.

4. What are the clinical manifestations of neurocysticercosis?

Many patients with NCC that eventually become symptomatic usually present to the emergency room initially. Clinical manifestations vary and are nonspecific, and are generally similar to those seen with other types of space-occupying lesions involving the brain. Parenchymal disease is most common and frequently presents with seizures in 50 to 80% of patients. Almost all patients will experience a headache at some point during their disease, and some may develop dementia if multiple parenchymal cysts are present. Patients with ventricular system involvement may present with rapid clinical deterioration from obstructive hydrocephalus, especially if the cyst blocks the foramen of Monro or aqueduct of Sylvius. Subarachnoid disease is usually more difficult to manage because the cysts are usually multiple, attain larger sizes, and produce severe basal meningitis (Wilkins and Rengachary, 1996, p 3397-3398)\textsuperscript{161}; (Psarros, et al., 2003, p 397-401)\textsuperscript{125}.

5. What laboratory work is required for patient’s suspected of having neurocysticercosis?

Patients suspected of having NCC generally require standard serum studies (complete blood count, peripheral eosinophil level), as well as, contemporary immunological serum testing for anticysticercal antibody levels which may include either the enzyme-linked immunosorbent assay (ELISA) or electroimmunotransfer blot (EITB) testing. Patients that present to the emergency room requiring ventriculostomy placement for obstructive hydrocephalus should also have their cerebrospinal fluid (CSF) analyzed for eosinophil and...
anticysticercal antibody levels in hopes of increasing the diagnostic accuracy. In mildly or moderately symptomatic patients that do not require ventriculostomy placement, lumbar puncture should initially be avoided unless diagnostic uncertainty exists after serological testing or there is not much concern about raised intracranial pressure. Contemporary serological methods (ELISA, EITB) hold promise for increasing diagnostic accuracy. Stool for ova and parasites is helpful in patients with simultaneous intestinal tapeworm infection, but is insensitive and nonspecific for T. solium species and is found in less than 33% of cases (Wilkins and Rengachary, 1996, p 3398)[161]; (Psarros, et al., 2003, p 397-401)[125].

6. What imaging studies are useful in this patient population?

High-resolution CT and MRI scanning are most commonly used for diagnosing NCC. MRI testing allows for better visualization of the scolex, which is diagnostic. If MRI is not available, a CT scan with contrast is useful. However, the presence of ventricular cysts may not be visible on CT scan, often requiring positive-contrast ventriculography to confirm the diagnosis, if MRI is not available. (Wilkins and Rengachary, 1996, p 3398-3400)[161]; (Psarros, et al., 2003, p 397-401)[125].

7. What is the mainstay of treatment for the various forms of neurocysticercosis?

**Parenchymal Disease**

The accepted treatment for parenchymal NCC is antihelminthic therapy. The two medications most commonly given are praziquantel (50 mg/kg/d in divided doses for 14 days) and albendazole (15 mg/kg/d for 1 month). Albendazole has a greater parasiticidal effect, better CSF penetration, does not adversely interact with steroids, and is cheaper than praziquantel. It has become the first-line medication for this disease, although the optimal dose and duration of treatment remains somewhat controversial. In the past it was generally given for 1 month, whereas more recently, studies documenting its efficacy over much shorter periods have surfaced. Current consensus guidelines suggest that antiparasitic therapy may be used with solitary viable or degenerating cysts, and are strongly indicated for multiple viable or degenerating cysts. A temporary increase in pericystic inflammation is often observed during treatment, as the dying parasite can no longer escape host defenses. For this reason, most physicians prescribe glucocorticoids concomitantly for a few days (dexamethasone 4 mg every 6 hours by mouth or intravenously) (Wilkins and Rengachary, 1996, p 3400-3402)[161], (Psarros, et al., 2003, p 397-401)[125].

If medical therapy fails, surgery has a role in select cases. Surgical intervention may include CT-guided stereotactic drainage, placement of a catheter-reservoir system for repeat aspiration, and craniotomy. The turbid and proteinaceous nature of the fluid within the sac or bladder oftentimes does not lend itself well to drainage procedures, especially during the later involuting stages when the walls harden (difficult to puncture) and the fluid becomes more dense. In the rare
patient that does require surgery for parenchymal lesions, they would probably be best suited by an open craniotomy procedure with cyst excision (Wilkins and Rengachary, 1996, p 3402)\[161\]; (Psarros, et al., 2003, p 397-401)\[125\].

**Subarachnoid/Cisternal Disease**

Cysts in the subarachnoid spaces are present in 27 to 56% of patients with NCC. These cysts are usually multiple, attain larger sizes than their parenchymal counterparts, and tend to induce a severe inflammatory reaction in the subarachnoid space. Although some large subarachnoid cysts, which have not yet induced an inflammatory reaction, can be safely managed surgically, involuting cysts that are no longer inert pose a challenge due to their size and adherence to eloquent anatomy. Increasingly, studies have shown a benefit with antihelminthics for both small and large cystic lesions in this compartment of the brain. Unfortunately, patients with basilar arachnoiditis and communicating hydrocephalus have a protracted course despite aggressive therapy. One study showed that mortality in patients with basal arachnoiditis and hydrocephalus was 50%, with most patients dying within 24 months of a shunting procedure (Wilkins and Rengachary, 1996, p 3402-3403)\[161\], (Psarros, et al., 2003, p 397-401)\[125\].

**Intraventricular Disease**

Intraventricular involvement occurs in approximately 15 to 20% of patients with NCC and is associated with high rates of mortality and morbidity.

**Medical Management**

Medical management is not advocated for patients with symptomatic hydrocephalus; however, controversy exists for patients harboring asymptomatic ventricular cysts. There are reports of successful treatment of ventricular cysts with antihelminthic medication and other reports that are not as promising. Some suggest, that even if treatment was effective in certain cases, their use should be contraindicated because death of the larvae within the ventricular system should be avoided. If medical therapy is attempted, worsening clinical or radiographic findings would be immediate indicators for shunting or surgical removal (Psarros, et al., 2003, p 397-401)\[125\].

**Shunting**

Shunting has been advocated by some as the definitive method of treating intracranial hypertension in patients with obstructive hydrocephalus and ventricular NCC for several reasons. First, because NCC is a chronic inflammatory disease, seeding of the subarachnoid cisterns results in communicating hydrocephalus, which can be relieved only by shunting. Second, ventricular shunting is faster, less damaging to the brain, uses smaller incisions with faster recovery times, and carries less morbidity than open surgical procedures. Third, some argue that open surgical resection can be avoided with shunting and antihelminthics. Although these arguments are valid, there are compelling reasons for surgical resection. In one study, seven patients underwent ventriculoperitoneal
shunting as the primary mode of therapy. Three patients needed a reoperation for cyst expansion at 8, 11, and 48 months. Furthermore, by 6 years, 50% of patients with shunts required at least one revision, and shunts associated with hydrocephalus secondary to NCC had higher failure rates. A recent retrospective review of shunt malfunctions among patients with neurocysticercosis found that shunts placed during the vesicular stage of cysticercal infection were twice as likely to malfunction compared with shunts placed during the degenerative or calcified stages of the disease. The same study also found that concurrent administration of antiparasitics after shunt placement during the vesicular stage greatly reduced the rate of shunt failure. Because it is difficult to predict which patients with ventricular cysticercosis will develop ventriculitis, CSF channel obstruction, and/or cyst expansion with antihelminthic therapy or shunting, some have advocated a more aggressive surgical strategy.

*Surgery*

Transcortical resection of lateral ventricular cysts, transcallosal or transcortical approaches for third ventricular cysts, and a suboccipital approach for fourth ventricular cysts are established microsurgical techniques for cyst excision. More recently, neuroendoscopy has become the primary treatment modality for ventricular cysticercosis at some institutions. It allows for internal CSF diversion in conjunction with cyst removal and avoids shunting. In addition, neuroendoscopy prevents the need for multiple craniotomies, gives access to the ventricular system in a matter of minutes, and allows for physiologic internal CSF drainage (Wilkins and Rengachary, 1996, p 3403)[161], (Psarros, et al., 2003, p 397-401)[125].

*End of case*