Imaging findings in neurocysticercosis

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Abstract

The diagnosis of neurocysticercosis was greatly improved by the introduction of computed tomography (CT) and magnetic resonance imaging (MRI). These techniques demonstrate the number and topography of lesions, their stage of involution, and the degree of inflammatory reaction of the host against the parasites and have largely replaced previous radiological procedures such as plain roentgenograms, pneumoencephalograms, cerebral angiography and myelo-graphy. In general, MRI provides better image detection and definition. The possibility of multiplanar reconstruction of images, its capability to visualize the posterior fossa without bone artifacts, and its high contrast resolution (far superior to that of CT) allow MRI to recognize many forms of cysticercosis not visualized on CT. However, the costs of MRI are high and the equipment is scarcely available in many endemic countries, and its sensitivity for the detection of calcified lesions is poor. CT remains the best screening neuroimaging procedure for patients with suspected neurocysticercosis, and MRI is the imaging modality of choice for the evaluation of patients with intraventricular cysticercosis, brainstem cysts and small cysts located over the convexity of cerebral hemispheres. Its better image definition also suggests that MRI is superior to CT in the follow-up of the patients after therapy.

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1. Introduction

Modern neuroimaging techniques, including computed tomography (CT) and magnetic resonance imaging (MRI), have improved the accuracy of the diagnosis of neurocysticercosis by providing objective evidence on the number and topography of lesions, their stage of involution, and the degree of inflammatory reaction of the host against the parasites (Garcia and Del Brutto, 2000). These imaging methods have largely replaced previous radiological procedures such as plain roentgenograms, pneumoencephalograms, cerebral angiography and myelography, which were once considered helpful diagnostic tools but currently have only limited importance. The first reports on the CT findings in neurocysticercosis were published in 1977 by Carbajal et al. (Carbajal et al., 1977) and Bentzon et al. (Bentzon et al., 1977). These pioneer studies were soon followed by a number of studies describing in detail the CT images in the different forms of this disease.
Lopez-Hernandez and Garaizar, 1982; McCormick et al., 1982; Mervis and Lotz, 1980; Rodacki et al., 1989). Radiological descriptions allowed the development of clinical classifications of neurocysticercosis based on the topography and evolutive stage of the lesions, and were of paramount importance for determining the rational therapeutic approach for the different forms of the disease (Garcia et al., 2002; Sotelo et al., 1985). Thereafter, MRI enhanced even more the accuracy of the neuroimaging diagnosis of neurocysticercosis. The possibility of multiplanar reconstruction of images, its capability to visualize the posterior fossa without bone artifacts, and its high contrast resolution (far superior to that of CT) allow MRI to recognize many forms of cysticercosis that are not well visualized by CT (Suss et al., 1986).

Intracranial calcifications are a common finding in patients with neurocysticercosis and in many cases represent the only evidence of the disease. The sensitivity of MRI for the detection of calcified lesions is poor, and thus CT remains the best screening neuroimaging procedure for patients with suspected neurocysticercosis. Currently, MRI is the imaging modality of choice for the evaluation of patients with intraventricular cysticercosis, brainstem cysts and small cysts located over the convexity of cerebral hemispheres. Its better image definition suggests that MRI is superior to CT in the follow-up of the patients after therapy. It should be noted, however, that the costs of MRI are high and the equipment is scarcely available in many endemic countries.

While some CT and MRI findings in neurocysticercosis are highly suggestive of this disease, the differential diagnosis with other infectious or neoplastic diseases of the central nervous system may be difficult. In such cases, a proper interpretation of data provided by clinical examination, immunodiagnostic tests, and epidemiological data, as well as the empirical administration of anticytiscercal drugs allow an accurate diagnosis in most cases (Del Brutto et al., 2001). The following pages will examine the neuroimaging characteristics of the most common types of neurocysticercosis.

2. Parenchymal neurocysticercosis

CT and MRI findings in parenchymal neurocysticercosis depend on the stage of development of the parasites. Vesicular (living) cysticerci appear on CT as small and rounded low-density areas that are well demarcated from the surrounding brain parenchyma (Fig. 1). These cysts lack perilesional edema and enhancement after contrast medium administration. Most of these lesions have in their interior an eccentric hyperdense nodule representing the scolex. On MRI, vesicular cysts appear with signal properties similar to those of CSF in both, T1- and T2-weighted images. The scolex is usually visualized within the cyst as a high intensity nodule giving the lesion a pathognomonic ‘hole-with-dot’ imaging (Fig. 1). Sometimes, these parasites are so numerous that the brain resembles a ‘swiss cheese’ (Fig. 2).

The process of degeneration of parasitic cysts involves a continuum that has been categorized by Escobar (1983) in four histopathological stages: viable, colloidal, nodular–granular and calcified. Colloidal cysticerci appear on CT and MRI as ill-defined lesions surrounded by edema. Most of them show a ring pattern of enhancement after contrast medium administration. Colloidal cysticerci represent the so-called ‘acute encephalitic phase’ of neurocysticercosis in which the host’s immune system is actively reacting against the parasite. On MRI, the wall of the cyst becomes thick and hypointense and there is marked perilesional edema; these findings are better visualized on T2-weighted images (Fig. 3).

A particular neuroimaging pattern of parenchymal neurocysticercosis is observed in patients with cystericotic encephalitis. In this severe form of the disease, both CT and MRI show diffuse brain edema and collapse of the ventricular system without midline shift. After contrast medium administration, multiple small ring-like or nodular lesions appear disseminated within the brain parenchyma (Rangel et al., 1987). These enhancing lesions represent relatively young cysticerci under severe immunological attack from the host (Fig. 4).

Parenchymal brain cysticerci may also appear on CT as nodular hyperdense lesions surrounded
by edema after contrast administration. This CT pattern correspond to the granular stage of cysticerci and is commonly referred as to ‘cysticercus granuloma’, or since it is usually a single parasite, ‘single enhancing lesion’ (Rajshekhar, 1991) (Fig. 5). On MRI, granular cysticerci are visualized as areas of signal void on both T1- and T2-weighted images. This MRI appearance provides diagnostic clues. Regardless of the imaging modality, the scolex of the cysticercus is never visualized in vivo. On imaging, it is rare to observe the scolex due to its position inside the ventricles or because of its lack of contrast enhancement as compared to the surrounding brain.
T2-weighted images surrounded by edema or gliosis with hyperintense rims around the area of signal void.

Calculated (dead) cysticerci normally appear on CT as small hyperdense nodules without perilesional edema or abnormal enhancement after contrast medium administration. As previously noted, these lesions are usually not visualized with MRI. It has recently been shown that calcified cysticerci may present perilesional edema and contrast enhancement, associated with symptom relapse (Nash et al., 2001) (Fig. 6).

3. Subarachnoid neurocysticercosis

Hydrocephalus, caused by inflammatory occlusion of the foramina of Luschka and Magendie, is the most common neuroimaging finding in patients with subarachnoid neurocysticercosis. Acute hypertensive hydrocephalus is associated with periventricular lucencies representing interstitial edema due to transependymal migration of CSF (Estandol et al., 1983; Sotelo and Marin, 1987). In contrast, chronic and relatively normotensive forms of hydrocephalus are not associated with this CT pattern. The fibrous arachnoiditis that is responsible for the development of hydrocephalus is seen on CT or MRI as areas of abnormal leptomeningeal enhancement at the base of the brain after contrast medium administration (Martinez et al., 1989) (Fig. 7).

Cystic subarachnoid lesions may be small when located within cortical sulci or may reach a large size if they are located in the Sylvian fissure or within the basal CSF cisterns (Fig. 8). Small cysts over the convexity of the cerebral hemispheres were considered rare in the first CT studies of neurocysticercosis. However, the development of new CT generations and the introduction of MRI allowed the recognition of the actual prevalence of such lesions. Small cysts within cortical sulci usually follow the same stages of involution that were described for parenchymal brain cysts and may be found in vesicular, colloidal, granular, or calcified stage. On the other hand, cystic lesions located within CSF cisterns may attain larger size since their growth is not stopped by pressure effects exerted by the brain parenchyma. These lesions usually have a multilobulated appearance, displace neighboring structures, and behave as mass occupying lesions. Ischemic cerebrovascular complications of subarachnoid neurocysticercosis are well visualized with CT or MRI. However, by themselves, such findings are non-specific since the
Fig. 6. (a and b) Calcified cysticerci on CT without edema or enhancement, and on MRI (surrounded by a wide area of edema).

Fig. 7. Fibrous arachnoiditis on contrasted CT.

Fig. 8. Giant cyst originating from the Sylvian fissure.
neuroimaging appearance of cysticercosis-related cerebral infarcts is the same of cerebral infarcts from other causes. In most patients, the association of subarachnoid cystic lesions (particularly at the suprasellar cistern) and the presence of abnormal enhancement of basal leptomeninges, as well as proper interpretation of clinical and CSF data, suggest the correct diagnosis (Del Brutto, 1992). Angiographic findings in subarachnoid neurocysticercosis include segmental narrowing or even occlusion of the major intracranial arteries in patients with cysticercotic-related cerebral infarcts (Fig. 9). While the actual frequency of these findings is unknown, a preliminary report suggests that angiographically documented arteritis is a relatively common finding in patients with subarachnoid neurocysticercosis, even in patients lacking clinical or neuroimaging evidence of a cerebral infarct.

4. Ventricular neurocysticercosis

Ventricular cysticerci appear on CT as hypodense lesions that distort the ventricular system causing asymmetric or obstructive hydrocephalus. Ventricular cysts are usually isodense with the CSF; therefore, they only can be inferred on the basis of distortion on the shape of the ventricular cavities (Madrazo et al., 1983). The administration of positive intraventricular contrast medium allows precise localization of intraventricular cysticerci by CT. The administration of contrast medium is usually performed by transcutaneous puncture of the antechamber of a ventricular shunt or through a ventriculostomy tube. Positive contrast medium may also be administered through a lumbar puncture; however, this procedure should be conducted cautiously since intracranial pressure may induce the development of brain herniation in patients with hydrocephalus or intraventricular masses.

Fig. 9. Ischemic cerebrovascular complications: angiographic findings (occlusion of a major intracranial artery).

Fig. 10. Ventricular cysts on MRI (Fluid-attenuated inversion recovery, FLAIR protocol).
Non-invasive diagnosis of intraventricular cysticerci represent one of the greatest advantages of MRI. Most ventricular cysts are readily visualized on MRI because the signal properties of the cystic fluid or the scolex differ from those of the CSF (Fig. 10). In some cysts, however, the scolex is not seen and the signal properties of the cyst are similar to those of CSF; in these cases, the ventricular cyst is only visualized in the proton-density sequence or with FLAIR techniques, where they appear barely hyperintense with regard to the CSF. Cyst mobility within the ventricular cavities in response to movements of the patient’s head, the ‘ventricular migration sign’, is better observed with MRI than with CT; this finding facilitates the diagnosis of ventricular cysticercosis in some patients (Rangel-Guerra et al., 1988).

5. Spinal cord neurocysticercosis

There is scarce information on the CT and MRI findings of spinal cysticercosis. Using CT, anecdotal reports have described symmetrical enlargement of the cord in a patient with intramedullary cysts and pseudoreticular formations within the spinal canal in a patient with leptomeningeal cysts. On MRI, intramedullary cysticerci appear as rounded or septated lesions that may have an eccentric hyperintense nodule representing the scolex. The periphery of the cyst usually enhances due to a breakdown of the blood–spinal barrier in the parenchyma of the spinal cord surrounding the cyst. The spinal cord is seen enlarged and if the scolex is not identified it is difficult to differentiate this condition from ependymomas, cystic astrocytomas, or primary syringomyelic cavities (Venkataramana et al., 1989). Myelography is still of diagnostic value in patients with suspected spinal leptomeningeal cysticercosis. In this form of the disease, myelograms usually show multiple filling defects in the column of contrast material corresponding to the cysts. Leptomeningeal cysts may be freely mobile within the spinal subarachnoid space and may change their position during the exam according to movements of the patient in the exploration table.

References


