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The Role of Contrast-Enhanced MR Imaging in the Diagnosis of Neurocysticercosis

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Pre- and postcontrast MR images of 17 patients with the diagnosis of neurocysticercosis were reviewed to evaluate the role of gadopentetate dimeglumine in MR imaging of this disease. The MR images, which were obtained on either a 0.5-T or 2.0-T superconducting system, revealed a total of 92 cysticerci in 17 patients. On contrast-enhanced T1-weighted images, 23 parenchymal cysticerci showed contrast enhancement. Ring-shaped enhancement was seen in only 6% (3/54) of cysticerci with intensity paralleling the CSF, while it was noted in 67% (16/24) of the cysticerci with intensity higher than CSF. Nodular enhancement was seen in granulomatous lesions with surrounding edema (29%, 4/14). Of 18 cysticerci with surrounding edema, 17 showed contrast enhancement. Basal meningeal enhancement, indicating meningitis, was observed in three patients.

The results indicate that contrast enhancement usually occurs in patients in whom precontrast MR findings have shown active inflammatory reaction in the degenerating stage of the worm. Thus, postcontrast imaging is useful in a limited number of patients with neurocysticercosis; it should be used selectively in those whose clinical or precontrast MR studies show meningitis, granulomatous lesions, or cysts with surrounding edema.

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MR imaging proved to be a useful imaging method in diagnosing neurocysticercosis and appears to be superior to CT in almost all patients with neurocysticercosis except those with only small calcification [1–9]. Although gadopentetate dimeglumine has increasingly been used in patients with CNS abnormalities [10], it remains undetermined whether the patient suspected of having neurocysticercosis should have contrast-enhanced MR imaging. The purpose of this study is to evaluate the role of gadopentetate dimeglumine in the MR evaluation of neurocysticercosis.

Subjects and Methods

Seventeen patients (14 men and three women) with neurocysticercosis who ranged in age from 29 to 67 years old (mean, 47.7 years) were studied with MR imaging before and after enhancement with gadopentetate dimeglumine, and the images were evaluated retrospectively. The diagnosis of neurocysticercosis was made on the basis of the combined results of the imaging findings and positive serologic test, enzyme-linked immunosorbent assay (ELISA) for cysticercus-specific immunoglobulin G (IgG) antibody in both serum and CSF. In eight patients diagnosis was confirmed surgically. In nonsurgically confirmed cases, MR findings of multiple round cysts, each containing a tiny eccentric nodule, representing the scolex of the worm, were considered as definite confirmation of neurocysticercosis, regardless of ELISA test. Such findings are virtually pathognomonic of neurocysticercosis, particularly in an endemic area such as Korea. When the scolex was not visible within the cysts, only the cases with both positive ELISA results in CSF and MR findings of multiple cysts were regarded as neurocysticercosis. The patients with MR findings of only nodular lesion(s) were not included here, regardless of ELISA results.

The MR images were obtained on a 0.5-T superconducting unit (Supertec-5000, GoldStar, Seoul) in seven patients and a 2.0-T superconducting unit (Spectro-20000, GoldStar, Seoul)

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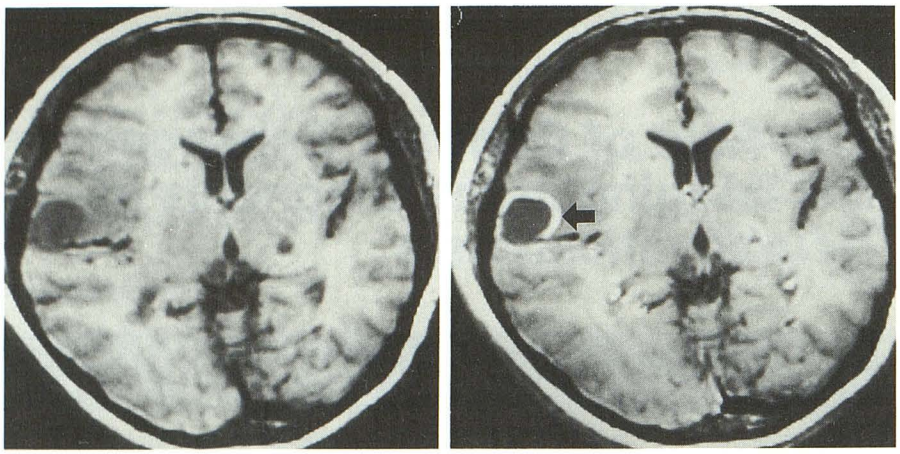

Fig. 1.—Cysticercosis in various stages.
A, Precontrast axial SE 500/30 MR image shows a cyst of low (but higher than CSF) intensity in right parietal lobe with surrounding edema of low intensity. Multiple small nodular lesions of iso- or low intensity are also seen in left frontal lobe, left thalamus, and right basal ganglia.
B, Contrast-enhanced axial SE 500/30 MR image shows thick, ring-shaped enhancement of cysticercus in right parietal lobe (*arrow*). There is also faint nodular enhancement in left thalamic lesion.

in 10 patients, with multiecho, multislice, spin-echo (SE) pulse sequences. Before contrast administration, T1-weighted (500/30, TR/TE) sagittal images and proton-density-weighted (2000–3000/30) and T2-weighted (2000–3000/80–100) axial images were obtained. After IV injection of gadopentetate dimeglumine (0.07–0.1 mmol/kg body weight), T1-weighted axial and sagittal, and sometimes coronal, images were obtained. The slice thickness/gap was 5 mm/2 mm for the 2.0-T unit and 7 mm/2 mm for the 0.5-T unit. In one case of spinal cord cysticercosis, slice thickness/gap was 3 mm/1 mm in the sagittal plane and 5 mm/2 mm in the axial plane. The acquisition matrix was 256 × 256, with spatial resolution of 1 mm × 1 mm. The number of excitations ranged from 4 to 6 for T1-weighted images and 1 to 2 for T2-weighted images.

The MR images were reviewed with attention to the location of cysticerci, pericysticercal edema, signal intensity of the cyst contents, presence and pattern of contrast enhancement, and their relationships, by two neuroradiologists and a senior radiology resident experienced with high-field MR imaging and the use of contrast material, together with all clinical information and results of ELISA.

Results

Ninety-two cysticerci were observed in 17 patients; 82 cysticerci were in the parenchyma, seven on the leptomeninges, two within the fourth ventricle, and one within the cervical spinal cord. Among the 92 cysticerci, contrast enhancement was shown in 23 parenchymal cysticerci in 10 patients: ring-shaped enhancement (Figs. 1–3) was seen in 19, and nodular enhancement (Fig. 4) in four. Of 54 cysticerci with signal intensity identical to that of CSF on all pulse sequences, only three revealed thin ring-shaped contrast enhancement. Sixteen of 24 cysticerci with signal intensity higher than that of CSF on T1- and proton-density-weighted images showed thin or thick ring-shaped enhancement (Figs. 1 and 3). The remaining 14 lesions had a nodular appearance on precontrast MR without cystic content; they measured 10 mm or less in diameter. Ten of the lesions appeared hypointense or isointense relative to brain parenchyma on precontrast T1- and T2-weighted images, and the other four appeared slightly hypointense on the T1-weighted images, and markedly hypointense on proton-density- and T2-weighted images. Of the former group (10 lesions), four with surrounding edema of variable degrees showed nodular or microring enhancement (Figs. 1 and 4), while none of the latter group (four lesions) demonstrated the contrast enhancement that proved to be calcifications on precontrast CT scans.

Seventeen of 18 lesions with surrounding edema of variable degrees were included in the 23 lesions with contrast enhancement. Only one of the 18 lesions with surrounding edema revealed no contrast enhancement. Twelve of 13 cysticerci with both surrounding edema and signal intensity higher than that of CSF on T1- and proton-density-weighted images enhanced; only four of 60 cysticerci both without surrounding edema and with signal isointense with CSF enhanced. The relationship between the focal contrast enhancement, the surrounding edema, and the appearance of the cysticerci is summarized in Table 1.

Three cases demonstrated meningeal enhancement. One case with multiple leptomeningeal cysticerci in the right sylvian

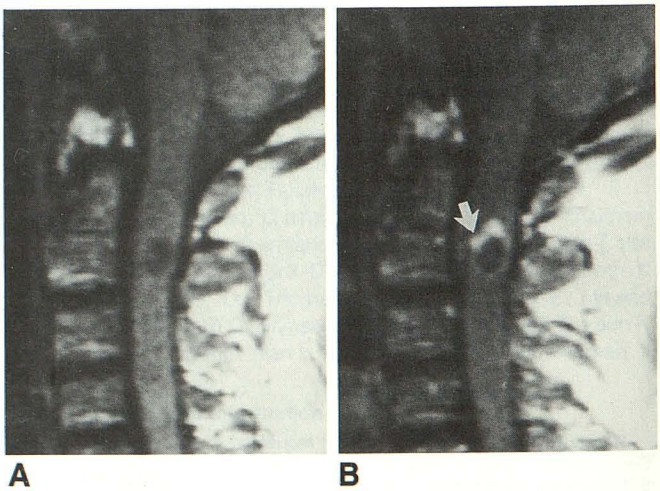

Fig. 2.—Cysticercosis of the spinal cord.
A, Precontrast sagittal SE 500/30 MR image shows cyst of low signal intensity with eccentric dotlike structure, suggesting a scolex in spinal cord at level of C2–C3.
B, Contrast-enhanced sagittal SE 500/30 MR image shows "signet ring-shaped" enhancement (*arrow*).

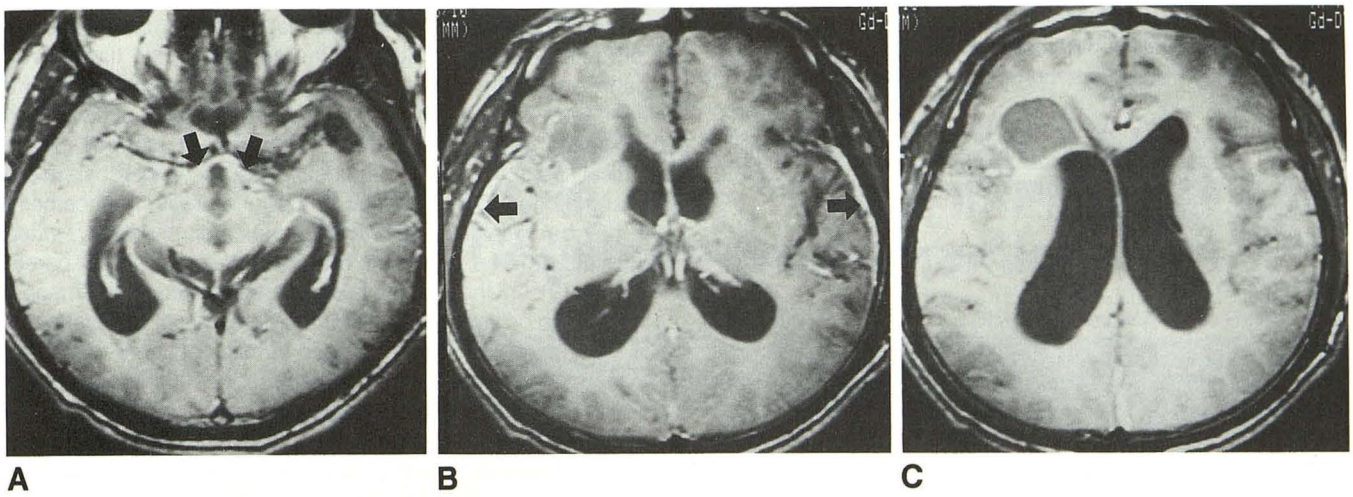

Fig. 3.—Cysticercal meningitis.
***A–C*, Contrast-enhanced SE 500/30 MR images show meningeal enhancement at suprasellar cistern and bilateral temporal convexities (*arrows*) in association with a cysticercus with ring enhancement in right frontal lobe.**

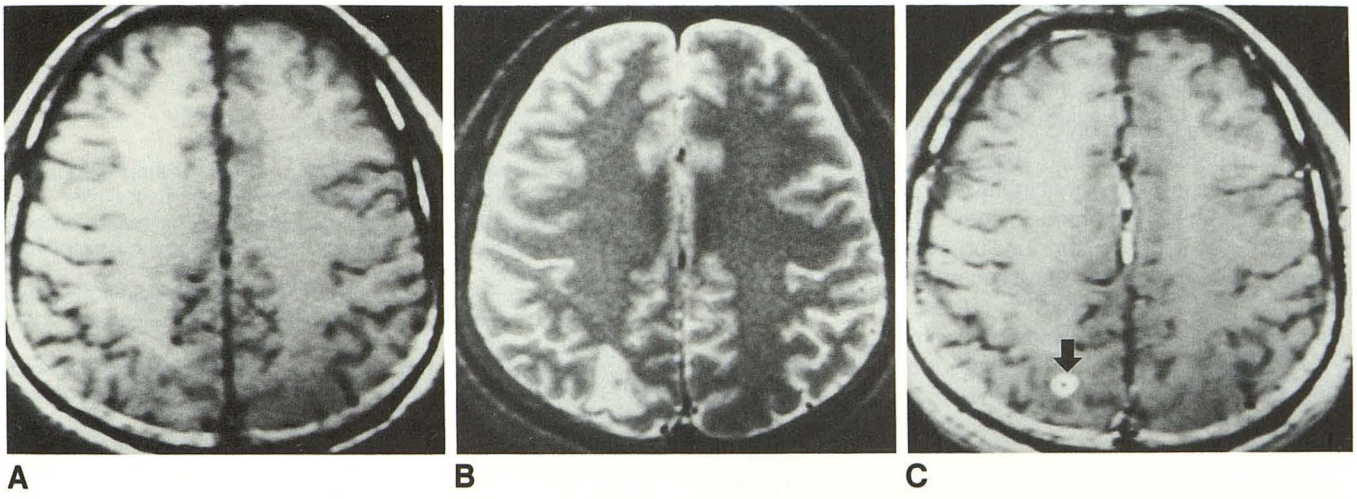

Fig. 4.—Cysticercosis in granulomatous nodular stage.
***A*, Precontrast SE 500/30 MR image shows small cysticercus of slight hypointensity or isointensity relative to brain parenchyma in right parietal lobe.**
***B*, Precontrast SE 3000/80 MR image shows surrounding edema of high signal intensity with a small central nodule of slightly low intensity.**
***C*, Contrast-enhanced SE 500/30 MR image shows nodular or microring-shaped enhancement of nodule (*arrow*).**

cistern showed linear meningeal enhancement in the right sylvian cistern. The second case revealed a solitary parenchymal cysticercus with ring enhancement in the right frontal lobe associated with meningeal enhancement along the suprasellar cistern and bilateral temporal convexities (Fig. 3). The remaining case, with cysticerci in the left frontal lobe and the fourth ventricle, demonstrated meningeal enhancement along the right sylvian cistern and left side of the tentorium in association with multiple subacute enhancing infarcts in both temporal lobes, the right thalamus, and pons.

Discussion

MR findings of neurocysticercosis are variable, depending on the stage in evolution of the infection [1, 2, 6, 7, 11, 12]. In the vesicular stage, the larva is seen as a small marginal nodule projecting into a cyst containing clear fluid. A thin capsule surrounds the cyst at this stage. The inflammatory reaction is well localized to the adjacent brain tissue and there may be only a small ring of edema and glial proliferation. In this stage, the cysticercus appears as a round cyst with a mural nodule (scolex) without enhancement or edema on MR and CT. The cystic fluid appears isointense with CSF on all MR pulse sequences [1, 2, 11]. In the present study, only 6% (3/54) of the cysticerci in the vesicular stage revealed contrast enhancement.

In the next stage (colloidal vesicular stage), the larvae begin to degenerate. The cyst fluid becomes turbid, and the capsule thickens. As the cysticerci degenerate, an acute encephalitic stage may ensue from humoral and tissue response to cysticerci, causing surrounding edema and enhancement on MR

TABLE 1: Relationship Between Contrast Enhancement, Edema Surrounding Lesions, and Appearance of Cysticerci

	Postcontrast Enhancement on MR		
	Positive	Negative	Total
Lesions with surrounding edema on precontrast MR			
Positive	17	1	18
Negative	6	68	74
Total	23	69	92
Appearance of cysticerci on precontrast MR			
Cystic type			
Fluid isointense with CSF[a]	3	51	54
Fluid hyperintense relative to CSF[b]	16	8	24
Nodular type			
Isointense with brain parenchyma[c]	4	6	10
Hypointense relative to brain parenchyma[d]	0	4	4
Total	23	69	92

[a] Isointense with CSF on all pulse sequences.
[b] Hyperintense relative to CSF on T1- and proton-density-weighted images.
[c] This group includes all the nodules of slight hypointensity or isointensity on all pulse sequences.
[d] This group includes all the nodules of slight hypointensity on T1-weighted images, and marked hypointensity on proton-density- and T2-weighted images.

and CT [1, 2, 11]. The enhancement is a result of an inflammatory reaction caused by degenerating larvae, which are known to release metabolic products that break down the blood-brain barrier [2, 6, 12]. The turbid cyst fluid is responsible for the signal intensity higher than that of CSF on T1- and proton-density-weighted images. On T2-weighted images, the cyst fluid and surrounding edema appear as high intensity, while the cyst wall and central scolex appear as low intensity [11]. In our series, 67% (16/24) of the cysticerci in this stage showed ring-shaped enhancement.

By the third (granular nodular) stage, the cyst has undergone retraction, its contents begin to mineralize, and its capsule is quite thick and collagenous. There is a steady decline and involution to granulomatous lesions, some of which may appear as enhancing nodules or microring-like lesions with or without surrounding edema [11, 12]. In our series, 10 cysticerci with isointense nodular patterns corresponded to this stage, and 40% (4/10) of them showed nodular or microring enhancement, suggesting granuloma.

By the final (nodular calcified) stage, the lesion is shrunken and completely mineralized. The granulomatous lesions are replaced by gliosis and, eventually, by calcified nodules [1, 2, 11, 12]. In the present series, four calcified nodules with hypointensity belonged to this stage; none of them showed contrast enhancement.

The results indicate that the contrast enhancement around the cysticerci seems to occur when there are both surrounding edema and signal intensity of the cyst contents higher than CSF on T1- and proton-density-weighted images. Such enhancement probably reflects degeneration of the worms and inflammatory reaction of the adjacent brain tissue. The degree of contrast enhancement on MR imaging may indicate the degree of focal parenchymal inflammatory reaction around the cysts, although contrast enhancement did not play a critical role in the actual diagnosis of neurocysticercosis in the vast majority of the patients. Without contrast enhancement, it may be difficult to identify the cysticerci, especially, when they are smaller than 1 cm and isointense with brain parenchyma [9]. In these cases, contrast-enhanced MR imaging appears to be indispensable for the detection of the cysticerci. In cysticercal meningitis, as seen in three patients with meningeal enhancement in the present series, it is impossible to identify the meningeal inflammation by precontrast MR imaging alone.

In conclusion, since precontrast MR imaging provides enough information to make a diagnosis of neurocysticercosis in the vast majority of patients, and contrast enhancement seems to be useful in a limited number of neurocysticercosis cases, it is suggested that contrast imaging be used selectively in patients whose clinical or precontrast MR studies show meningitis, granulomatous lesions, or cysts with surrounding edema.

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