Case Report

Use of Diffusion-Weighted MR Imaging in Differential Diagnosis Between Intracerebral Necrotic Tumors and Cerebral Abscesses

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Summary: The differential diagnosis between intracerebral necrotic tumors and cerebral abscesses is frequently impossible with conventional MR imaging. We report two cases of cerebral abscesses that showed high signal on diffusion-weighted echo planar imaging and a strongly reduced apparent diffusion coefficient. This appearance was not present in our cases of necrotic/cystic gliomas (eight cases) and necrotic metastases (two cases). We believe that diffusion-weighted MR imaging may be a diagnostic clue in cases of cerebral “ring-enhancing” masses.

Technical Case Report

Both patients were examined with routine MR and diffusion-weighted echo-planar imaging on a Siemens Vision 1.5-T unit (Siemens, Erlangen, Germany). MR imaging included axial T2-weighted fast spin-echo sequences (parameters: 5000–6000/128 [TR/TE], one or two signals acquired; a 6-mm section thickness; an echo train length of 23; a 192 × 256 or 230 × 512 matrix; and a 184 × 205 or 230 × 230-mm field of view) and axial T1-weighted spin-echo sequences (parameters: 600/14 [TR/TE], two or three signals acquired; a 6-mm section thickness; a 220 × 256 matrix; and a 230 × 230-mm field of view) were obtained before and after an injection of gadolinium.

Diffusion-weighted imaging included an axial echo-planar spin-echo sequence (800/123, 10 or five signals acquired; a 6-mm section thickness; a 128 × 200 matrix; a 280 × 280-mm field of view; three b values (0, 300, 1200 mm²/sec); a sensitising gradient in the z direction in all cases, and occasionally in the x and y directions). The duration (δ) and the amplitude (G) of the pulsed gradients were 26 ms and 0, 11, 22 mT/m, respectively. The distance between the leading edges of the two pulsed gradients (Δ) was 59.7 msec. The apparent diffusion coefficient (ADC) maps were calculated in the z direction and the calculations of trace were not performed.

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weighted sequences (1). Nonetheless, a ring-enhancing mass is a nonspecific imaging finding that can be seen in various noninflammatory benign and neoplastic processes. The differential diagnosis includes primary brain tumors (e.g., necrotic glioblastoma), metastases, resolving hematoma, infarction, and even demyelinating disease (1). In our two reported cases of cerebral abscesses, the CT and conventional MR images were also nonspecific.

Proton MR spectroscopy also has been used in the characterization of intracranial mass lesions. Poptani (2) reported that the presence of cytosolic amino acid residues, along with lactate and acetate, suggests the lesion is an abscess. Lactate levels, however, also are increased in gliomas, schwannomas, and epidermoid cysts. In another study of brain tumors with proton spectroscopy, Ott (3) reported the presence of N-acetyl aspartate, choline, creatinine, and lactate in a single case of abscess. These discrepancies may be attributed to partial volume effect. The reports of Poptani (2) and Schumacher (4) suggest that localized proton MR spectroscopy may be a specific test for the identification of abscess.

Diffusion-weighted MR imaging also was used occasionally in the diagnosis of cerebral abscesses.
In 1996, Ebisu (5) reported a case of brain abscess (*Streptococcus intermedius*) with a high signal intensity in the abscess cavity on diffusion-weighted images associated with a low ADC value ($0.31 \times 10^{-3} \text{ mm}^2/\text{s}$). He concluded that diffusion-weighted imaging might enable one to distinguish brain abscesses from cystic or necrotic tumors.

Nevertheless, in 1997, Krabbe (6) reported another case of abscess with low signal intensity in the abscess fluid and a high ADC value. Our results, as well as those reported by Ebisu, are in contradiction with the ADC value for an abscess as reported by Krabbe. A possible explanation for this discrepancy may be a partial volume effect (ie, only one 8-mm slice was used for diffusion-weighted imaging and contamination by surrounding edema is possible) or motion (examination time of 30 minutes with motion-sensitive spin-echo technique). In our study, the slice thickness was 6 mm and the number of slices averaged 15, which minimized the effects of partial volume and eventual motion between conventional MR (used for selection of diffusion-weighted imaging in study of Krabbe) and diffusion-weighted imaging.

Diffusion-weighted MR imaging is reported to be highly sensitive and specific for the diagnosis of...
acute cerebral infarction (7–10). Lövblad et al (11) reported only two false-positive findings in 194 cases of acute ischemic stroke. One false-positive finding was a cerebral abscess, and the other was a brain tumor. ADC values, however, were not calculated in this study, and the T2 (shine-through) effect remains a possible explanation for these findings.

The reported ADC values for acute ischemic stroke vary in value with time. Lutsep (10) reported $0.29 \pm 0.33 \times 10^{-3}$ mm$^2$/sec for ischemic lesions, studied less than 8 hours after symptom onset, $0.61 \pm 0.14 \times 10^{-3}$ mm$^2$/sec at 8 to 24 hours, and $0.51 \pm 0.18 \times 10^{-3}$ mm$^2$/sec at 1 to 8 days. Mean normal ADC values for the entire group ($n = 26$) were $0.88 \pm 0.12 \times 10^{-3}$ mm$^2$/sec.

In our cases, the mean ADC values in the central part of the abscess were 0.29 and 0.27, respectively. These values are $\pm 50\%$ lower than those 8 hours after an ischemic stroke.

Our results and the literature support the idea that reduced ADC values in the central part of the abscess are related to the presence of pus. Ebisu (5) also performed an in vivo diffusion-weighted imaging of aspirated pus, as well as ADC measurements. The pus imaged in vitro showed high signal intensity and very low ADC values, consistent with the results of the in vivo study. He concluded that the pus structure itself is responsible for the low ADC values, and that the heavily impeded water mobility of pus may be related to its high cellularity and viscosity. The presence of large molecules, like fibrinogen, also may play a key role in restricting the diffusion of pus (12).

On the other hand, the cystic or necrotic components of tumors show a marked signal suppres-
sion on diffusion-weighted MR images, similar to that of CSF, and the calculated ADC values are in the range of $2.2 \pm 0.9 \times 10^{-3} \text{ mm}^2/\text{sec}$ (13).

We also retrospectively reviewed the diffusion-weighted images and ADC maps of intracerebral tumors with a ring-enhancing presentation on CT and conventional MR studies (six glioblastomas, two pilocytic astrocytomas, and two metastases). All of them also showed increased diffusion of necrotic/cystic components (Figs 3 and 4).

**Conclusion**

Brain abscesses are potentially fatal lesions, and a correct diagnosis should be established as soon as possible. Establishing the differential diagnosis between intracerebral necrotic tumors and cerebral abscesses is frequently impossible with conventional MR imaging. Our experience, along with that of Ebisu, suggests that diffusion-weighted MR imaging and ADC maps are very useful in the differential diagnosis of ring-enhanced cerebral masses. The presence of central hyperintensity on diffusion-weighted MR images and very low ADC values strongly suggest the presence of pus and abscess. The differential diagnosis includes acute infarction, which also shows hyperintensity on diffusion-weighted MR images and reduced ADC values. Nevertheless, the ring enhancement in acute ischemic stroke is very unusual, and ADC values are higher after 8 hours.

The ring-enhancing mass with central hypointensity on diffusion-weighted MR images and an increase in ADC values suggest necrotic tumor, most frequently cerebral glioma or metastasis. For these reasons the diffusion-weighted images and calculations of ADC values should be per-
formed in all cases of ring-enhanced cerebral masses.

References