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Fast Fluid-Attenuated Inversion-Recovery MR of Intracranial Infections

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PURPOSE: To assess the usefulness of fast fluid-attenuated inversion-recovery (FLAIR) MR sequences in the diagnosis of intracranial infectious diseases. METHODS We compared fast FLAIR images with conventional spin-echo images (T1- and T2-weighted) obtained in 20 patients with infectious diseases (six with encephalitis, five with brain abscesses, three with meningitis, two with meningoencephalitis, two with Creutzfeldt-Jakob disease, one with epidural empyema, and one with cysticercosis). Two neuroradiologists independently reviewed the FLAIR images and compared them with the conventional spin-echo images, obtaining agreement in all patients. RESULTS: FLAIR images of diagnostic quality were obtained in 18 patients. In two patients, FLAIR images were degraded by motion. Lesions in the patients with encephalitis and meningoencephalitis were better delineated on FLAIR images than on spin-echo images. FLAIR images clearly depicted lesions in the basal ganglia in both patients with Creutzfeldt-Jakob disease. In patients with brain abscess, meningitis, cysticercosis, and epidural empyema, FLAIR images provided no more information than conventional spin-echo images, and the lesions were seen better on postcontrast T1-weighted spin-echo images. CONCLUSION: Fast FLAIR images showed pathologic changes in intracranial infectious diseases better than or as well as conventional T2- and proton density-weighted spin-echo sequences. However, postcontrast T1-weighted spin-echo sequences resulted in better visibility of abscess, meningitis, cysticercosis, and epidural empyema than did FLAIR images.

Index terms: Brain, infection; Brain, magnetic resonance


The fluid-attenuated inversion recovery (FLAIR) sequence is a T2-weighted imaging technique that generates heavily T2-weighted and cerebrospinal fluid (CSF)-nulled MR images (1–5). Because these sequences are modified inversion-recovery sequences, their use has been limited by long scanning times. However, by combining a fast or turbo spin-echo sequence with an inversion-recovery sequence (fast or turbo FLAIR), scanning time can be greatly reduced (6).

Use of FLAIR imaging in infectious disorders and in other inflammatory processes, such as sarcoidosis, has shown promising results (1, 4, 5, 7). In these reports, FLAIR imaging was stated to be more sensitive than T2-weighted spin-echo imaging in a limited number of patients. We therefore determined to assess the utility of fast FLAIR sequences as compared with conventional spin-echo sequences, including postcontrast T1-weighted spin-echo imaging, in the diagnosis of intracranial infections.

Materials and Methods

The subjects consisted of 20 patients (12 male and eight female, 5 to 78 years old) with a variety of intracranial infectious diseases. These included three patients with herpes simplex encephalitis, three with encephalitis caused by other viruses, five with brain abscess, three with meningitis (one tuberculous and two pyogenic), two with meningoencephalitis caused by an unknown organism, two with Creutzfeldt-Jakob disease, and one patient each with epidural empyema and cysticercosis. The diagnosis
was confirmed by surgery in six patients with brain ab-
scesses or epidural empyema. In the remaining 14 pa-
tients, the diagnosis was made on the basis of clinical,
imaging, and laboratory findings and the patients’ re-
sponse to antibiotic therapy.

We used 1.5-T and 0.5-T MR units. In 17 patients ex-
amined on a 1.5-T unit, we used FLAIR imaging se-
quences with parameters of 6000,9000/119/1 (repetition
time/echo time/excitations) and an inversion time of 2060
or 2200. For one patient, we used another 1.5-T unit and
a different FLAIR sequence (9980/160/1) with an inver-
sion time of 2000. In the remaining two patients, we used
two 0.5-T units and FLAIR sequences of 6000/88,120/2
with an inversion time of 1700. Other imaging parameters
were as follows: imaging matrix, 98–256 \times 192–256; sec-
tion thickness, 5 to 10 mm; and field of view, 15–23 \times
20–23 cm. Scanning time ranged from 2 minutes to 6
minutes 24 seconds.

Two neuroradiologists blinded to the clinical data as-
sessed the FLAIR images, comparing them with conven-
tional spin-echo images, which included T2- and proton
density–weighted fast spin-echo images and precontrast
and postcontrast T1-weighted spin-echo images. They
rated the FLAIR images as superior, equal, or inferior to the
spin-echo images. The assessment resulted in agreement
between the two neuroradiologists in all patients.

Results

The FLAIR images were degraded by motion
artifacts in one patient with encephalitis and in
another with Creutzfeldt-Jakob disease, but we
obtained images of diagnostic quality in the oth-
ers.

The lesions in the patients with encephalitis or meningoencephalitis were seen better on the
FLAIR images than on the T2- or proton densi-
ty–weighted spin-echo images (Fig 1). Involv-
ment of the gray matter tended to be well de-
picted on FLAIR images, with good contrast
with CSF. In the patients with Creutzfeldt-Jakob
disease, both of whom were in the early stage,
the FLAIR images showed the lesions in the
basal ganglia slightly better than did the T2- or
proton density–weighted spin-echo images, al-
though the images of one of them were de-
graded by motion (Fig 2). In two of five patients
with brain abscesses, FLAIR images were
judged superior to T2- or proton density–
weighted spin-echo images in showing hypoin-
tensity of the capsule. However, in all patients
with brain abscesses, postcontrast T1-weighted
spin-echo images delineated the capsule better
than any other sequence (Fig 3). Likewise, in
patients with meningitis, cysticercosis, and epi-
dural empyema, FLAIR images provided no
more information than conventional spin-echo
images, including the postcontrast T1-weighted
spin-echo images. However, it was noteworthy
that the cisternal lesions in the patient with tu-
berculous meningitis were more conspicuous
on FLAIR images than on T2- or proton density–
weighted images, as they appeared hyperin-
tense relative to CSF on FLAIR images (Fig 4).
In eight patients, hyperintensity due to hydro-
cephalus and/or perifocal edema was better de-
picted on FLAIR images than on T2- or proton
density–weighted images.

Discussion

The FLAIR technique is a recently developed
method of obtaining T2-weighted images with
nulling of the CSF signal (1–5). This technique
is an inversion-recovery sequence that reduces
the signal from CSF and attains heavy T2
weighting with the use of a long echo time. The clinical utility of FLAIR images has been assessed in several intracranial conditions (1, 2, 4, 6, 8–13). FLAIR imaging has proved to be useful in head injury, multiple sclerosis, acute subarachnoid hemorrhage, carbon monoxide poisoning, tuberous sclerosis, and mesial temporal sclerosis (8–13), but its usefulness has been reported to be limited in the diagnosis of intracranial tumors (6). The use of FLAIR sequences in the diagnosis of intracranial infectious diseases has been reported in a limited number of patients (1, 5, 7).

In our series, FLAIR images delineated lesions related to encephalitis and Creutzfeldt-Jakob disease more clearly than on T2- and proton density–weighted images. FLAIR images yielded particularly high lesion contrast in encephalitic lesions. Encephalitis frequently involves the gray matter. Because artifacts from CSF motion and CSF volume averaging with the brain parenchyma are minimized and because the signal from CSF is reduced, FLAIR images result in better visibility of gray matter lesions. Our experience with cisternal lesions in a patient with tuberculous meningitis may be similarly explained (Fig 4). In addition, although not essential in the diagnosis of these diseases,
FLAIR images showed hyperintensity due to hydrocephalus and/or perifocal edema better than did the T2- or proton density–weighted images. The usefulness of postcontrast MR imaging has been widely accepted in the evaluation of intracranial infectious diseases (14–16). Our results indicate that postcontrast T1-weighted spin-echo images are superior to FLAIR images in delineating enhancing lesions, such as the capsules in brain abscess, cysticercosis, and epidural empyema. Similarly, cisternal or meningeal abnormalities associated with meningitis were more clearly depicted on postcontrast T1-weighted spin-echo images than on FLAIR images. Enhancing lesions on postcontrast T1-weighted spin-echo images reportedly also show enhancement on postcontrast FLAIR images (6). So far, we have had no experience with postcontrast FLAIR images in patients with meningitis.

Although patients with intracranial infectious diseases are frequently uncooperative, we were able to obtain FLAIR images of diagnostic quality in all but two patients in this series. We applied an inversion pulse to multiple fast spin-echo radio-frequency signal complexes in a relatively long inversion time. This greatly contributed to the short scanning time and the increase in number of sections obtained per one scan. Recently, it has become possible to acquire FLAIR images by using echo-planar sequences in a shorter scanning time. We are in the process of investigating the usefulness of this technique for imaging patients with infectious brain disorders.

We encountered several difficulties with FLAIR images. First, there were various types of artifacts. Hyperintense artifacts related to CSF flow motion were frequently noted near the foramen of Monro, aqueduct, posterior fossa cisterns, and fourth ventricle, and we also encountered artifactual hyperintensity lining the wall of the lateral ventricles. Fortunately, the former did little to hinder us in formulating a diagnosis. The latter, however, may simulate the pathologic hyperintensity seen with ventriculitis; therefore, postcontrast T1-weighted images may be required to make the correct diagnosis. Second, because FLAIR images are T2-weighted, the same as long-repetition-time spin-echo images, the findings were not always specific. For example, perifocal edema could not be definitely differentiated from encephalitis. Third, in our experience, lesions in the brain stem (eg, lacunar infarcts) tend to be inadequately depicted as compared with supratentorial lesions on FLAIR images. Therefore, although not a problem in our series, the diagnostic utility of FLAIR imaging for brain stem lesions may be limited.
In conclusion, fast FLAIR images showed pathologic changes in several intracranial infectious diseases better than conventional T2- and proton density–weighted spin-echo sequences. Its short scanning time was advantageous in examining patients with these diseases, since many of them are uncooperative and clinically unstable. The postcontrast T1-weighted spin-echo sequence, however, remains indispensable in some conditions, such as brain abscess, meningitis, cysticercosis, and epidural empyema.

References