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MRI of head injury using FLAIR

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Abstract We studied the utility of fluid-attenuated inversion-recovery (FLAIR) MRI in the investigation of head injury. We examined 56 patients with head injuries with T2-weighted spin-echo (SE) and FLAIR sequences. In all cases, the sensitivity of FLAIR images to equal or superior to that of conventional SE images to the traumatic lesions. In 9 cases, central diffuse axonal injury of the fornix and corpus callosum could be seen only on sagittal FLAIR images.

Key words Brain, injury · Fluid-attenuated inversion-recovery (FLAIR) magnetic resonance imaging

Introduction

Although T2-weighted spin-echo (SE) sequences have been widely accepted as a sensitive MRI technique for examining the brain, they have some important limitations. One is that the high signal from cerebrospinal fluid (CSF) can obscure lesions adjacent to CSF. The fluid-attenuated inversion-recovery (FLAIR) sequence suppresses the signal from CSF by using a long inversion time (TI). It can markedly improve the image quality of brain lesions adjacent to CSF [1–3]. We evaluated this technique for investigation of patients with head injuries.

Subjects and methods

We studied 56 patients with head injuries, 38 males and 18 females, mean age 29 years. MRI was obtained 1–36 days after head injury, mean 9.5 days. Classification of the head injuries was according to Gentry et al. [4, 5]. Because surgical confirmation was not available in most of the patients, traumatic lesions were considered true-positive if seen with two different sequences (T2-weighted SE, FLAIR) or in two planes.

We used a 0.5 T superconducting imager, performing a FLAIR sequence [4000/1500/100/2 (TR/TI/TE/excitations)] and T2-weighted SE sequence [2000–2500/100/1 (TR/TE/excitation)] in all patients. The slice thickness of the FLAIR sequences was 8 mm, matrix size 192 × 128, 1 acquisition taking 12 min 48 s.

The relative sensitivity of the SE and FLAIR images in anatomically matched slices was assessed. Reading of the images was by two trained neuroradiologists. The chi-square test was used for statistical evaluation.

Results

Table 1 shows the comparison of T2-weighted SE and FLAIR images.

The FLAIR images were significantly more sensitive than T2-weighted SE images ($P < 0.01$) to diffuse axonal injury (DAI), cortical contusion and subdural haematomas (Table 1). In cases of epidural haematoma and brain stem injury, there was no statistical difference, because of the small number of cases.

In 38 lesions with presumed DAI, FLAIR images were superior to T2-weighted SE images in 19 cases (50%) (Figs. 1, 2), and of equal value in 19 (50%). In 9 of 31 patients with DAI of the corpus callosum FLAIR images showed the lesions as abnormally high signal in the septum pellucidum and/or fornix (Fig. 1). In these cases, only sagittal FLAIR images showed the lesions in the fornix (Fig. 1 b), and only FLAIR images delineated DAI of the splenium (Fig. 1 c).

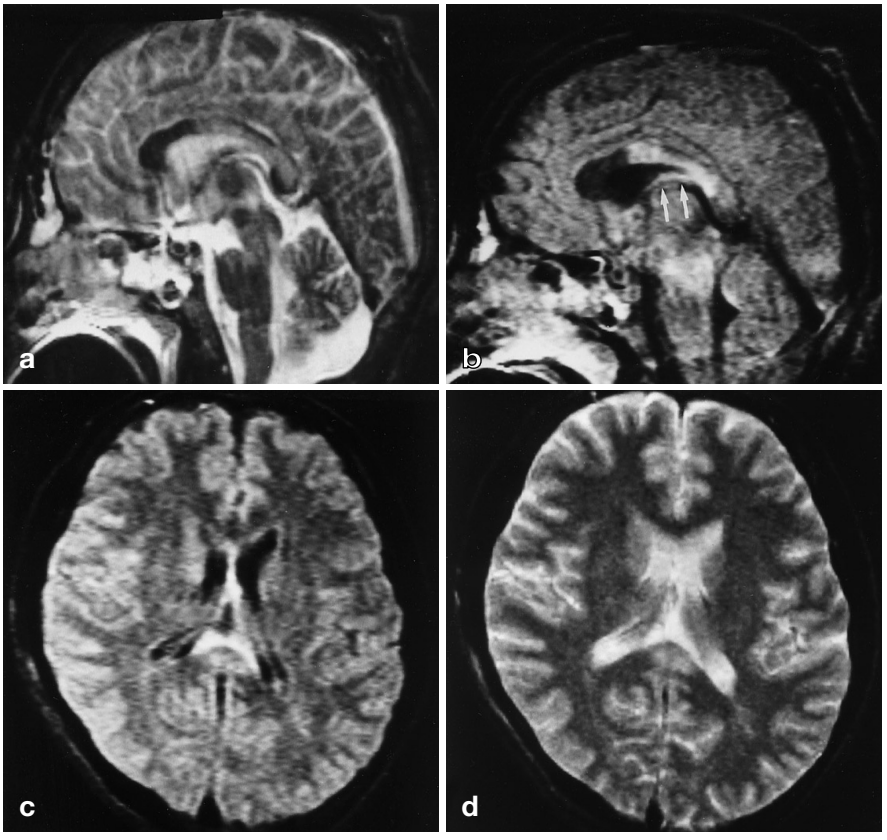

Fig. 1 a–d An 18 year-old man with diffuse axonal injury (DAI) of corpus callosum. Although the sagittal images (**a, b**) reveal the lesions in the corpus callosum as high signal, only the FLAIR image (**b**) can delineate them clearly from CSF in the ventricle. A lesion extending to the fornix is shown only on the sagittal FLAIR image (**b**; *arrows*). The traumatic lesion in the septum pellucidum is shown only on the axial FLAIR image (**c**), and is not found on the spin-echo image (**d**) at all

In 32 cases of cortical contusion, FLAIR images were superior to T2-weighted SE images in 25 (78%) (Fig. 3, and of equal value in 7 (22%).

In 24 subdural haematomas FLAIR images were superior to T2-weighted SE images in 19 (79%) (Fig. 4), and of equal value in 5 (21%). With epidural haematomas, FLAIR images were superior in 3 (30%), and of equal value in 7 (70%). In brain stem injury, FLAIR images were superior in 3 cases (43%) (Fig. 2), and of equal value in 4 (57%).

Discussion

FLAIR is an inversion-recovery sequence designed to null or greatly reduce signal from CSF, and enables very heavy T2 weighting without high signal and potential artefacts from CSF [1–3].

It has been reported that MRI is superior to CT for detecting many traumatic lesions [4–9]. Gently [4] found images with long TR/short TE and long TR/TE were most sensitive to traumatic lesions in the brain over the whole time-course of injury.

Most DAI lesions are at the grey-white matter interface and spare the overlying cortex. Traumatic damage to the fornix and septum pellucidum often occurs in association with DAI of the corpus callosum [4, 7]. As most traumatic lesions, including DAI, cortical contusion, brain stem injury and epidural and subdural haematomas are close to CSF these lesions may not be reading detectable on conventional T2-weighted images, because both lesion and CSF give high signal. The high tissue-contrast between grey and white matter on T2-weighted SE may also obscure small lesions of high signal intensity at or on the surface of the brain. By suppressing the signal from CSF and the tissue-contrast between grey and white matter, the FLAIR sequence considerably improves the ability of MRI to demonstrate traumatic head injury. Small lesions at the periphery of the cerebral hemispheres, such as cortical contusion and subdural haematomas, were detected only on FLAIR images (Figs. 3 b, 4 b).

Although traumatic damage to the fornix and septum pellucidum can be seen as an abnormally thick and high-signal zone on T2-weighted images [4, 7], it is rather difficult to discriminate from CSF in the ventricle. In such cases, sagittal FLAIR images are more useful (Fig. 1 b). For the first time, we were able to show traumatic lesions of the fornix and septum pellucidum. We found sagittal FLAIR images useful and recommend that they be used routinely when patients may have

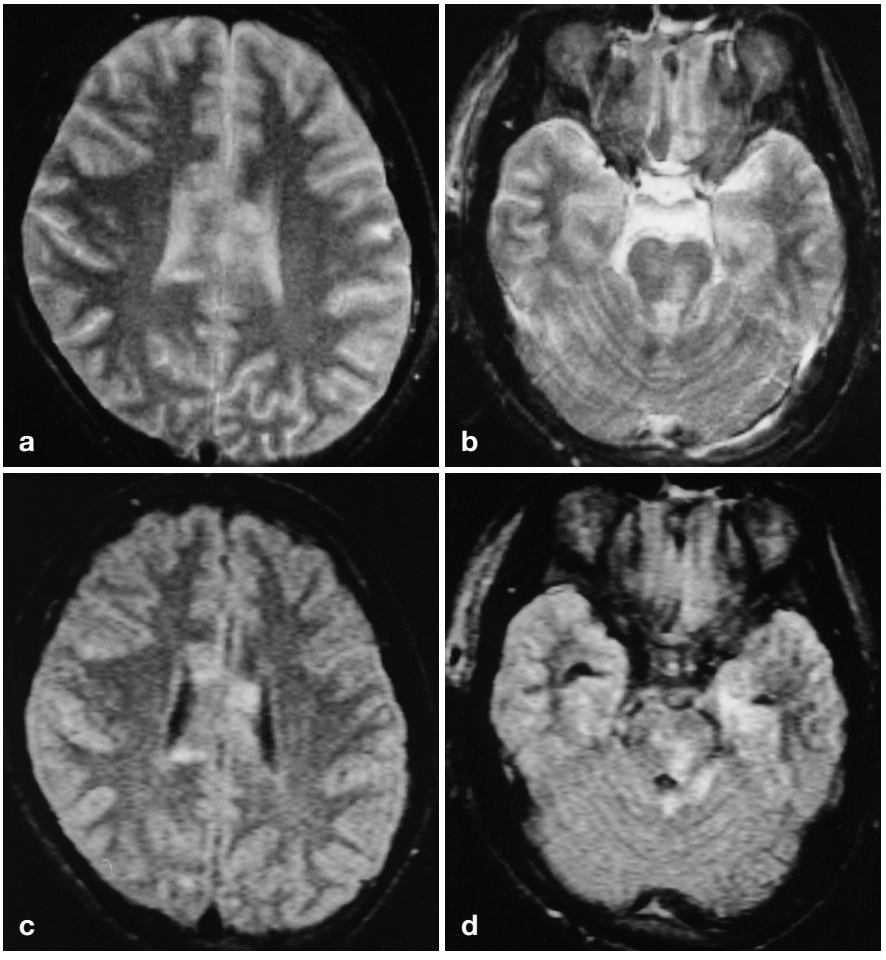

Fig. 2a–d An 18-year-old man with brain stem injury and DAI of the corpus callosum. Axial SE (**a, b**) and FLAIR (**c, d**) images. The FLAIR images give much better definition of the lesion. DAI of the corpus callosum and a left dorsolateral midbrain abnormality are readily seen on the FLAIR images

Table 1 Visibility of traumatic lesions using T2-weighted spin-echo (SE) and FLAIR images

Sequences	Lesion				
	Diffuse axonal injury	Cortical contusion	Subdural haematoma	Extradural haematoma	Brain stem injury
FLAIR only[a]	2 (5)*	15 (47)*	15 (63)*		
FLAIR > SE[b]	17 (45)*	10 (31)*	4 (16)*	3 (30)	3 (43)
FLAIR = SE[c]	19 (50)	7 (22)	5 (21)	7 (70)	4 (57)
FLAIR < SE[d]					
SE only[e]					
Total	38	32	24	10	7

* $p < 0.01$ (chi-square test with continuity correction)
[a] Only FLAIR images showed lesion
[b] FLAIR superior to spin-echo images
[c] Both FLAIR and SE images of equal value
[d] SE images superior to FLAIR
[e] Only SE images showed lesion

DAI, because traumatic lesions associated with DAI are often located centrally in the brain.

Although disadvantages of FLAIR include a long examination time and the fact that it yields fewer slices than the SE sequence, the diagnostic information obtained outweighs these drawbacks. The fast FLAIR sequence, which yields 18 sections in a short acquisition time, can overcome these difficulties [10].

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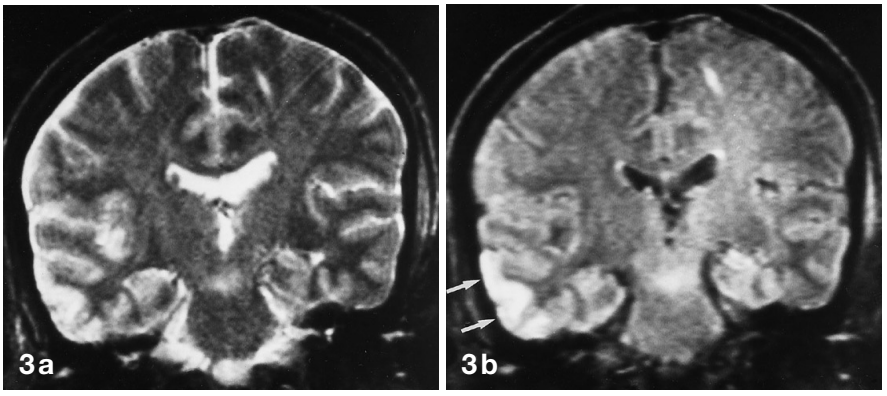

Fig. 3 a, b A 61-year-old man with cortical contusion. Coronal T2-weighted SE (**a**) and FLAIR (**b**) images demonstrate contusion of the right temporal lobe *(arrows),* but **b** shows it much more clearly

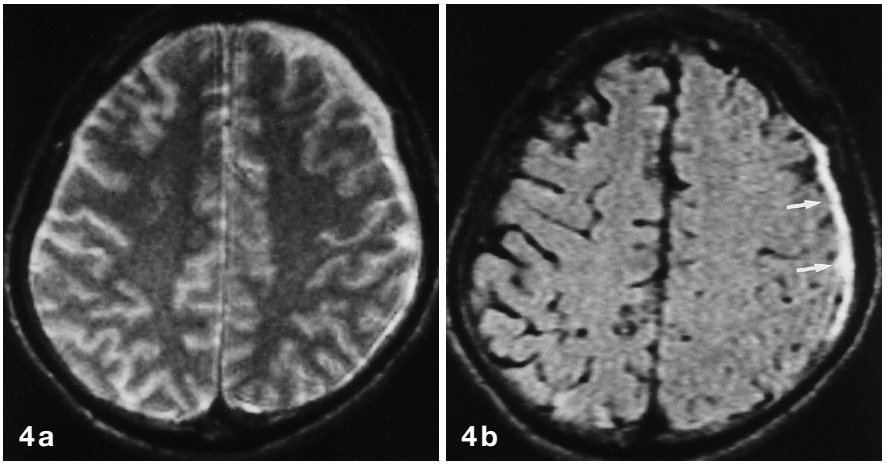

Fig. 4 a, b A 55-year-old woman with a subdural haematoma. Axial SE (**a**) and FLAIR (**b**) images. **b** shows a crescentic extra-axial collection as high signal *(arrows),* indicating that it is not simply an effusion but a subdural haematoma. This subtle change cannot be detected in **a**

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