

# The Significance of Fast Fluid-Attenuated Inversion Recovery MR in Encephalomalacia and Encephalopathy

Hye-Young Choi · Hyon-Joo Kwag · Myung-Hun Kim\*

Department of Radiology, Neurosurgery,\* Neurology Division, Ewha Medical Research Center,  
College of Medicine, Ewha Womans University

= 국문 초록 =

## 뇌연화증과 뇌병증에서의 FLAIR 영상의 유용성

이화여자대학교 의과대학 의과학 연구소 신경학부, 방사선과학교실, 신경외과학교실\*  
최혜영 · 곽현주 · 김명현\*

**목 적 :** 뇌연화증과 뇌병증의 진단에 있어서 Fluid-Attenuated Inversion Recovery (FLAIR) 자기공명영상 (Magnetic Resonance Image, MRI)의 유용성을 알아보고자 하였다.

**방법 및 대상 :** 뇌연화증 8예와 뇌병증 4예 총 12예를 대상으로 하였으며 모든 예에서 FLAIR영상 (TR/TE/TI = 10000/119/2500)과 급속스핀에코영상 (T2강조영상, 3500/85, T1강조영상, 433/11)을 얻어서 그 차이점을 비교분석하였다. 병소는 양성과 고형성 부분으로 나누어서 분석하였으며 고형성 부분은 다시 회백질과 백질부위로 나누어서 신호강도를 분석하였다.

**결 과 :** 8예의 뇌연화증중 6예가 스핀에코영상의 T1강조영상에서 저신호강도, T2강조영상에서 고신호강도를 나타내고 FLAIR 영상에서는 뇌척수액의 신호강도와 같은 신호강도를 보임으로써 양성 변화를 한 곳을 뚜렷하게 보여 주었다. 주위의 백질변화도 전체 8예에서 T2강조영상보다 훨씬 뚜렷한 고신호강도를 보여 인접한 회백질과 차이가 있어 회백질과 백질을 구분할 수가 있었다. 회백질에도 변화가 있었던 6예중 4예는 백질의 변화와는 달리 오히려 T2강조영상에서 더 고신호강도를 보였으나 주위의 양성 병소나 백질 변화와의 구분은 FLAIR영상에서 더 잘 되었다. 뇌병증 4예중 3예는 기저핵이 T1강조영상에서 고신호강도를 보였는데 이는 FLAIR영상에서 각각 다른 신호강도를 나타내었다. 1예의 저산소성 뇌병증에서는 스핀에코영상에서 전혀 보이지 않던 병소들을 FLAIR영상에서 뚜렷하게 볼 수 있었으며 다른 1예의 특성 뇌병증과 함께 백질 병소가 T2강조영상에 비해서 더 잘 인지되었다. 1예의 간성 뇌병증에서는 백질 병소가 T1강조영상에서만 고신호강도로 인지할 수 있었으며 나머지 1예인 백질이영양증 환아는 광범위한 백질 병소가 T2강조영상과 FLAIR영상에서 별 차이가 없었다.

**결 론 :** FLAIR영상은 스핀에코영상만으로는 알 수 없는 병변의 특성을 구분할 수 있게 할 뿐 아니라 안보이던 부분을 찾을 수 있게 해 주어 스핀에코영상과 더불어 보완적 검사로서 그 유용성 및 가치가 있을 것으로 사료되었다.

**KEY WORDS :** FLAIR MRI · Encephalomalacia · Encephalopathy.

## Introduction

The advantages of FLAIR imaging include improved contrast between the signal intensity of a variety of diseases that prolong brain T2 relaxation and the suppressed signal intensity of the adjacent ventricular or subarachnoid cerebrospinal fluid(CSF)<sup>1)</sup>. Therefore, we expected that FLAIR imaging could make it easy to detect an abnormal signal intensity within a lesion of a variety of encephalopathy and delineate a cystic change of encephalomalacia. We performed this study to determine the usefulness of fast fluid-attenuated inversion-recovery(FLAIR) sequence in the evaluation of encephalomalacia and encephalopathy.

## Materials and Methods

We experienced 8 cases of encephalomalacia and 4 cases of encephalopathy. The causes of encephalomalacia were post-traumatic changes in 6 cases and post-operative changes in 2 cases. The causes of encephalopathy were hypoxic encephalopathy, toxic encephalopathy, acquired hepatocerebral degeneration, and leukodystrophy.

MR was performed with 1.5 T scanner(GE Medical System, Milwaukee, U.S.A.). Axial T1-weighted (TR/TE=433/11msec), T2-weighted(TR/TE=3500/85msec), and FLAIR images(TR/TE/TI=

10000/119/2500msec) were obtained. Axial FLAIR images were selectively scanned at the lesion of interest which was already detected on axial T1- and T2-weighted images. So, number of slice and scan time were variable from 3 to 8 and 2 minutes to 8 minutes, respectively.

The signal intensities detected on FLAIR images were analyzed and compared with spin echo images. The main concern was to distinguish cystic and solid portions in a lesion as well as lesions of gray and white matter. We analyzed signal intensity of the cystic portion, white matter lesion, and gray matter lesion on T1-, T2-weighted image, and FLAIR image. And then, lesion conspicuity of the FLAIR image was compared with T2WI.

## Results

We retrospectively analyzed 8 cases of encephalomalacia and 4 cases of encephalopathy. On the Table 1 and 2, age of the patients, causes of the lesions, location and radiologic features of the lesions were described.

In 8 encephalomalacia, 6 cases showed low signal intensity similar with CSF intensity within the lesions on FLAIR, that revealed lower signal on T1W and high signal on T2W images. So, we could find the cystic portions within the lesions(Fig. 1, 2). On FLAIR, surrounding gliotic portions were demonstrated very

**Table 1.** Summary of 12 patients with encephalomalacia and encephalopathy

Case	Sex/Age	Diagnosis	Location
1	M/27	post-traumatic encephalomalacia	Rt. frontal lobe, Rt. basal ganglia
2	M/36	post-traumatic encephalomalacia	Lt. Parietal lobe
3	M/37	post-traumatic encephalomalacia	both frontal lobes
4	F/57	post-traumatic encephalomalacia	Rt. temporal lobe
5	M/39	post-traumatic encephalomalacia	Rt. temporal lobe
6	M/23	post-traumatic encephalomalacia	Lt. Frontal lobe
7	M/14	post-operative encephalomalacia	Rt. temporal lobe
8	F/47	post-operative encephalomalacia	Lt. Frontal lobe
9	M/2	leukodystrophy	diffuse white matter
10	M/35	hepatocerebral degeneration	diffuse white matter, basal ganglia
11	F/65	toxic encephalopathy	diffuse white matter, basal ganglia
12	M/23	hypoxic encephalopathy	diffuse white matter, basal ganglia

Rt. : right, Lt. : left

**Table 2.** MR findings of encephalomalacia and encephalopathy

Case	Cystic change	SI of white matter			SI of gray matter			Lesion conspicuity		
		T1WI	T2WI	FLAIR	T1WI	T2WI	FLAIR	cystic	WM	GM
1	+	Low	High	High	Low	High	High	>	>	<
2	+	Iso	High	High	Low	High	High	>	>	<
3	-	Low	High	High	Low	High	Iso	-	>	<
4	+	Iso	Iso	High	Iso	High	Iso	>	>	>
5	+	Iso	High	High	Iso	Iso	High	>	>	>
6	-	Iso	Iso	High	-	-	-	-	>	-
7	+	Iso	High	High	-	-	-	>	>	-
8	+	Iso	High	High	Low	High	High	>	>	<
9	-	Low	High	High	-	-	-	-	=	-
10	-	High	Low	Iso	High	Low	Low	-	=	=
11	-	Low	High	High	High	Low	Iso	-	>	=
12	-	Iso	Iso	High	Low	High	High	-	>	>

SI : signal intensity, T1WI : T1-weighted image, T2WI : T2-weighted image, FLAIR : Fluid-Attenuated Inversion Recovery Image

> : FLAIR image is superior to T2WI, = : FLAIR image is similar with T2WI, < : FLAIR image is inferior to T2WI

high signal intensity than regional parenchyma and more definitely defined than T2WI(Fig. 2). Four of six patients who showed the noncystic gray matter change revealed more high signal intensity on T2WI, however, FLAIR image was better to distinguish from cystic and gliotic lesions(Fig. 2).

In 4 encephalopathy, 3 patients showed the high signal intensity at the basal ganglia on T1WI, which revealed different signal intensity in each on FLAIR (Fig. 4). Hypoxic encephalopathy demonstrated new additional high signal lesions on FLAIR. In encephalopathy, white matter lesions were more well defined in toxic and hypoxic cases on FLAIR(Fig. 3, 4). In acquired hepatocerebral degeneration, abnormal high signal intensity depicted only on T1WI. Primary leukodystrophy showed same signal intensity on both T2-weighted and FLAIR images.

## Discussion

The FLAIR sequences are reported to be particularly useful in detecting subtle changes at the periphery of the cerebral hemispheres, around the basal cisterns, in the brain stem, at gray white matter interface, and in the periventricular region. These are sites where CSF artifacts and partial volume effects

between gray and white matter cause problems in diagnosis with conventional T2WI. On the other hand, on FLAIR, hyperintense areas are seen in normal adults in structures such as the centrum semiovale and parieto-occipital tract<sup>2</sup>. The increased signal intensity in the subependymal region may be due to the presence of long T2 components in white matter from transudation of CSF<sup>3</sup>. The high signal observed in white matter remote from the ventricular system may come predominantly from unmyelinated or sparsely myelinated fibers in all or part of the relevant white matter tract<sup>3</sup>.

The inversion-recovery sequences null or markedly reduce the signal from CSF and long echo time(TE) versions produce heavy T2 weighting. The very high T2 weighting may increase the conspicuity of abnormal increased signal intensity lesion on FLAIR. The fact that the CSF also has a low signal intensity means that these abnormal high signal intensities are not obscured by partial volume effects between CSF and white matter as may be the case with conventional T2-weighted spin-echo sequences<sup>4,5</sup>.

The cystic portions of encephalomalacia are easily defined on FLAIR images than spine echo T2WI because of the difference of signal intensity between cystic portion and surrounding gliotic portion by nul-

ling effect of the CSF. Cystic portions within the lesions show similar signal intensity with the CSF and surrounding gliotic portions are hyperintense on T2WI and FLAIR. Clinical significance of differentiation between cystic and gliotic portion of the lesion is not reported and may not be necessary to make a treatment plan. But imaging diagnosis of the encephalomalacia can be performed exactly on FLAIR image than spin echo image.

We could clearly defined the cystic and gliotic changes from diffuse encephalomalacia and found new additional lesions in encephalopathy on FLAIR images. In conclusion, FLAIR technique is useful and supplement study in evaluation of the encephalomalacia and encephalopathy.

### Summary

**Purpose :** To determine the usefulness of fast fluid-attenuated inversion recovery (FLAIR) magnetic resonance (MR) technique in evaluation of encephalomalacia and encephalopathy.

**Materials and Methods :** We studied postoperative and post-traumatic encephalomalacia in 12, post-infarct encephalomalacia in 6, and encephalopathy in 4 patients. The signal intensities were analyzed and compared FLAIR with spin-echo images by focusing at cystic and solid portions and also gray and white matter areas.

**Results :** In 18 encephalomalacia, 16 (89%) cases showed low signal intensity similar with CSF within the lesions on FLAIR, that revealed lower signal on T1WI and high signal on T2WI. So, we could find the cystic encephalomalacia within the lesions. On FLAIR, surrounding gliotic white matter portions were more definitely defined than T2WI as very high signal intensity in contrast to regional parenchyma. FLAIR

was better distinguished from regional cystic and gliotic portions. In 4 encephalopathy, 3 patients showed the high signal intensity at the both basal ganglia on T1WI, which revealed different signal intensities on FLAIR. On FLAIR, white matter lesions were more well defined in toxic and hypoxic cases.

**Conclusion :** We could clearly define the cystic and gliotic changes and find new additional lesions in encephalomalacia and encephalopathy on FLAIR images. We concluded that FLAIR technique was useful and supplement study in evaluation of the encephalomalacia and encephalopathy.

### References

- 1) Coene B, Hajnal JV, Gatehouse P, Longmore DB, White SJ, Oatridge A, et al : *MR of the brain using fluid-attenuated inversion-recovery (FLAIR) pulse sequences. AJNR 1992 ; 13 : 1555-1564.*
- 2) Tetsuhito M, Satoshi I, Yoshifumi K, Kazumasa S, Masashi N, Masayuki M, et al : *Serial cerebral MRI with FLAIR sequences in acute carbon monoxide poisoning. J Compt Assist Tomogr 1995 ; 19(4) : 631-634*
- 3) Hajnal JV, De Coene B, Lewis PD, Baudouin CJ, Cowan FM, Pennock JM, et al : *High signal regions in normal white matter shown by heavy T2-weighted CSF nulled IR sequences. J Compt Assist Tomogr 1992 ; 16(4) : 506-513*
- 4) Hajnal JV, Bryant DJ, Kasuboski L, Pattany PM, Coene BD, Lewis PD, et al : *Use of fluid-attenuated inversion-recovery (FLAIR) pulse sequences in MRI of the brain. J Compt Assist Tomogr 1992 ; 16(6) : 841-844*
- 5) Alexander JA, Sheppard S, Davis PC, Salverda P : *Adult cerebrovascular disease : Role of modified rapid fluid-attenuated inversion-recovery sequences. AJNR 1996 ; 17 : 1507-1513*

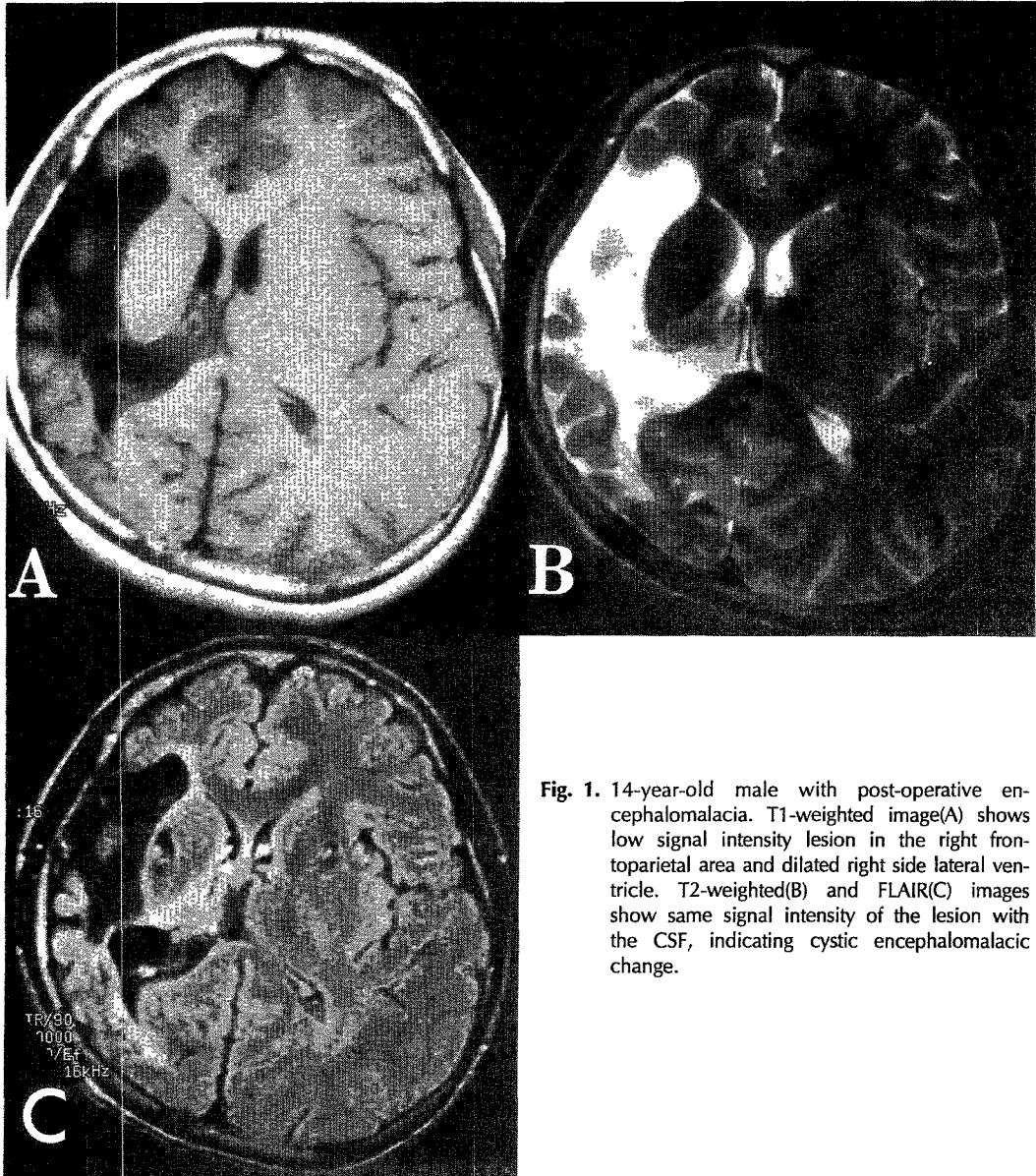


Fig. 1. 14-year-old male with post-operative encephalomalacia. T1-weighted image(A) shows low signal intensity lesion in the right frontoparietal area and dilated right side lateral ventricle. T2-weighted(B) and FLAIR(C) images show same signal intensity of the lesion with the CSF, indicating cystic encephalomalacic change.

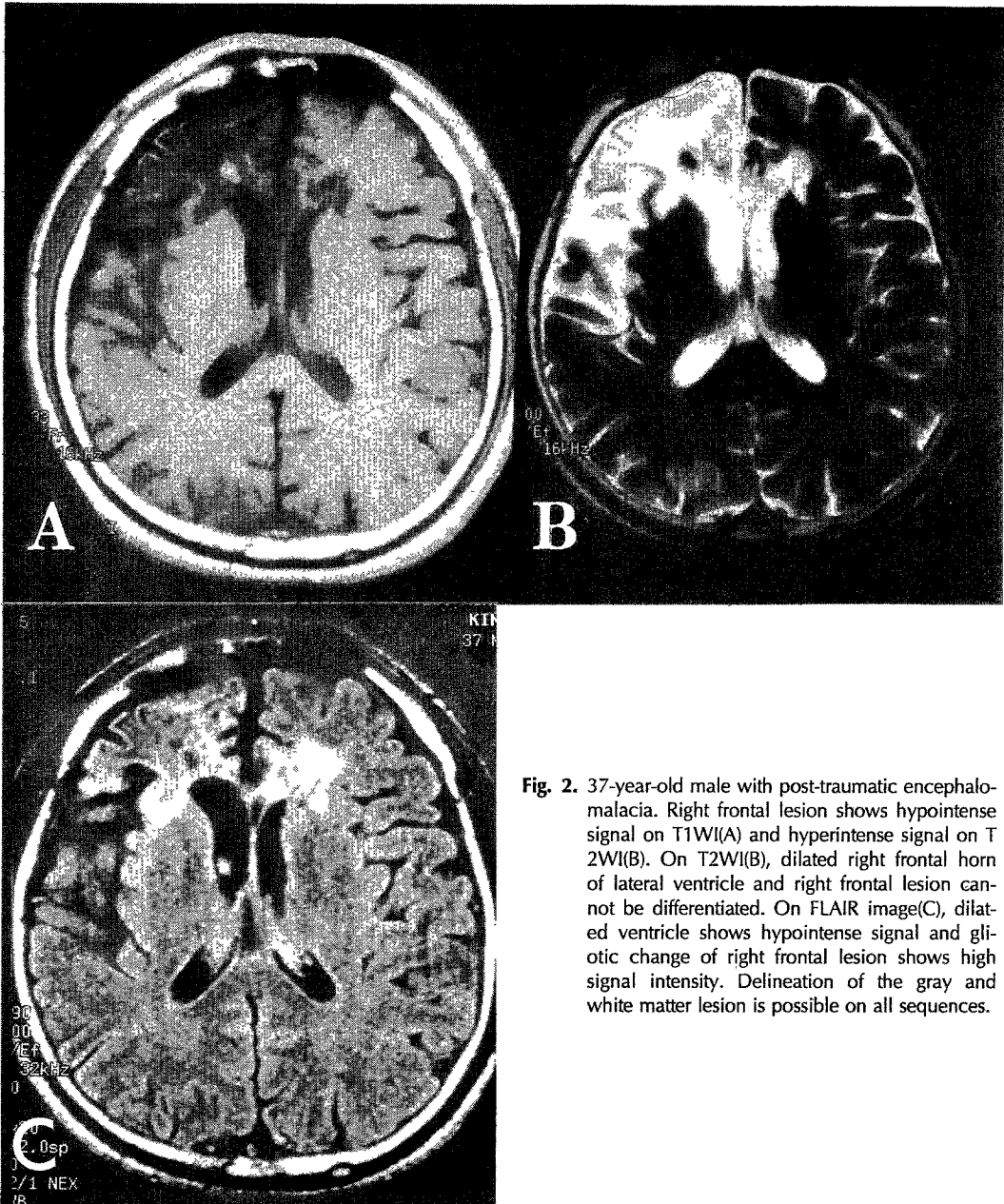


Fig. 2. 37-year-old male with post-traumatic encephalomalacia. Right frontal lesion shows hypointense signal on T1WI(A) and hyperintense signal on T2WI(B). On T2WI(B), dilated right frontal horn of lateral ventricle and right frontal lesion cannot be differentiated. On FLAIR image(C), dilated ventricle shows hypointense signal and gliotic change of right frontal lesion shows high signal intensity. Delineation of the gray and white matter lesion is possible on all sequences.

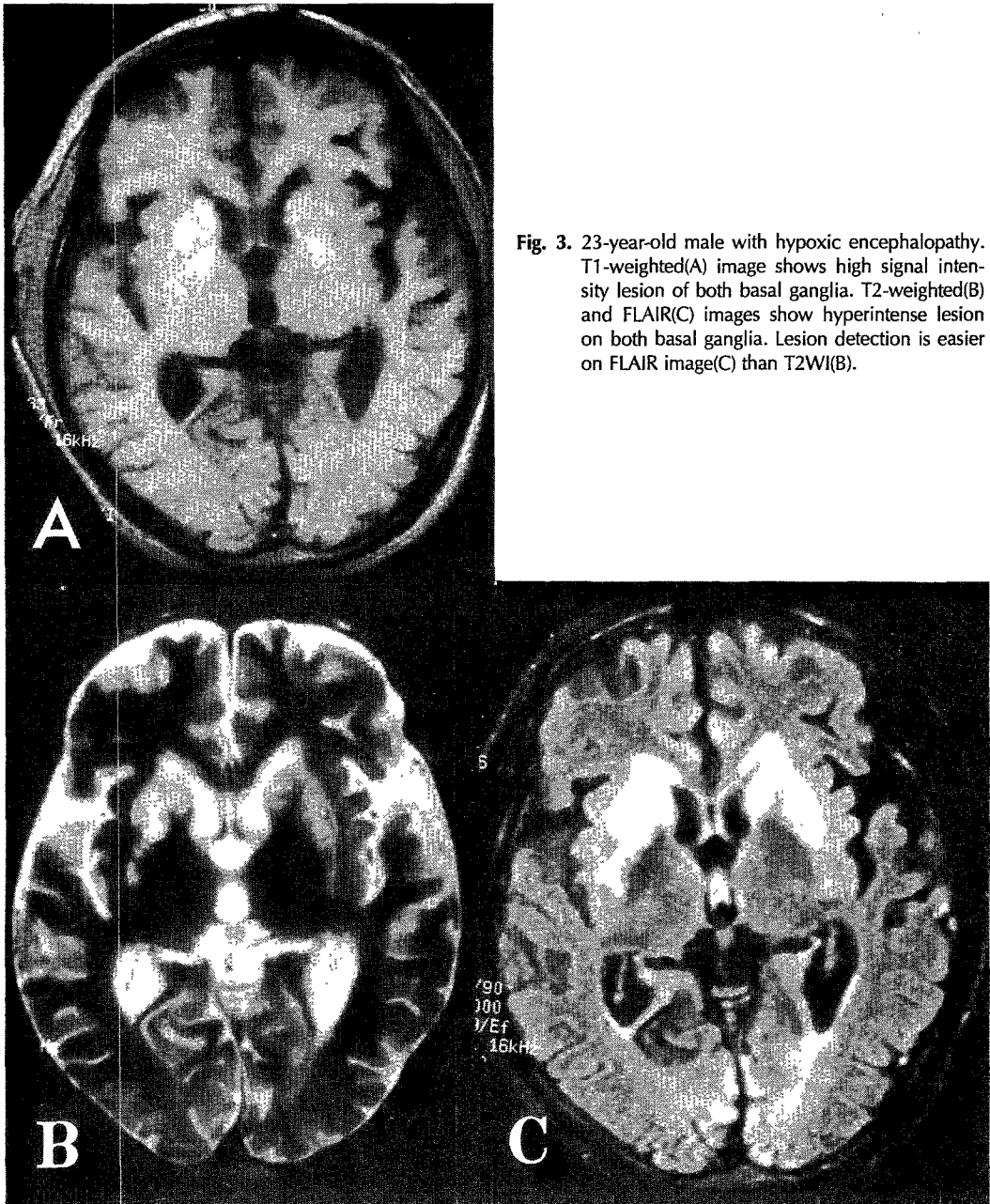
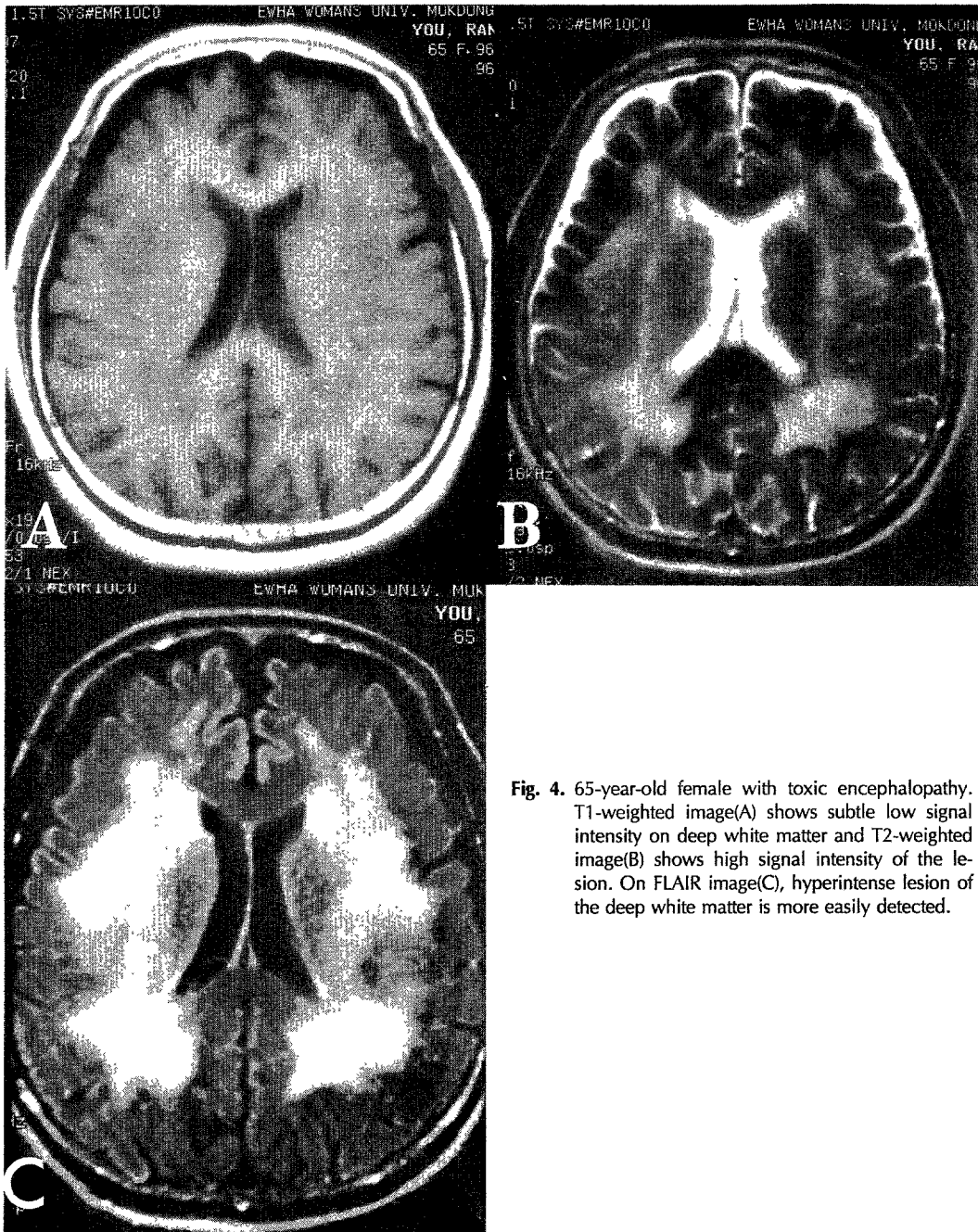


Fig. 3. 23-year-old male with hypoxic encephalopathy. T1-weighted(A) image shows high signal intensity lesion of both basal ganglia. T2-weighted(B) and FLAIR(C) images show hyperintense lesion on both basal ganglia. Lesion detection is easier on FLAIR image(C) than T2WI(B).



**Fig. 4.** 65-year-old female with toxic encephalopathy. T1-weighted image(A) shows subtle low signal intensity on deep white matter and T2-weighted image(B) shows high signal intensity of the lesion. On FLAIR image(C), hyperintense lesion of the deep white matter is more easily detected.