1

.   2

:   T1, T2
(diffusion weighted image ; DWI)
.

:   DWI   (MRI)
34   .
MRI   (3   ) 8 ,   (7   ) 10 ,
(4   ) 7 ,   (3   ) 4 ,   (3   ) 5
. MRI   1.5T   , T1   (T1WI)
T2   (T2WI)   DWI   . T1WI,
T2WI   DWI   ,
-              (SIR)   .
:   8   5 (24   )   / /
(T1WI/T2WI/DWI)   , 3 (72   )   / /
10   / /   ,   7   / /
,   4   / /   ,   5
/ /   .   -   T1WI
5   1.42± 0.78/2.58± 0.84/1.35± 0.08 (T1WI/T2WI/ DWI),
3   0.94± 0.18/0.63± 0.16/0.27± 0.10,   1.35±
0.01/0.97± 0.21/0.86± 0.22,   1.58± 0.04/1.54± 0.09/1.44± 0.14,
1.26± 0.11/1.06± 0.14/0.97± 0.12,
0.65± 2.23/1.51± 0.12/0.23± 0.18   .
:   DWI   T2WI   DWI
DWI
.

(magnetic resonance imaging ; MRI)
(1- 3).
.   DWI
MRI   .
.   .
(diffusion weighted image ; DWI)   MRI
,
MRI   (4, 5).   (gra-
dient echo, GRE)   (fluid attenu-
ated inversion recovery, FLAIR)

1
2

(6).   T1   T2

DWI

.

T1, T2

DWI

.

DWI   (fast
spin echo MRI ; FSE MRI)
34
.   22:12
44- 79 (62)   .
24 ,   10
.

MRI   (3   )
8 ,   (7   )10 ,   (4   )
7 ,   (3   ) 4 ,   (3
) 5   .   10
(computed tomog-
raphy, CT)   .   MRI
13.5   .   CT

11   ,
CT
CT
MR
13   .
CT   QX/i LightSpeed(General Electronics,
Milwaukee, U.S.A.)   High Speed Advantage (General
Electronics, Milwaukee, U.S.A.)   10 mm,

:

5 mm
. MRI   1.5T   (GE Horizon
Echospeed, Milwaukee, U.S.A.)   T1
(T1 weighted image ; T1WI)   FSE T2
(T2 weighted image ; T2WI)
(single shot echo planar image; SSEPI)   DWI
. FSE T2
TR 400 msec, TE 100 msec, echo- train length (ETL)
10 ,   5 mm,   2 mm,   22× 16 cm,
NEX(number of excitation) 1 ,   256× 192
,   3   25   . SS- EPI- DWI
TR 10000msec, TE 100 msec,   5 mm,
1.5 mm,   28× 21 cm,   128× 128, NEX
1   24- 31 , b value 1000sec/mm²
.   x,y,z
.

T1WI, T2WI   DWI

, ,
.   T1WI,
T2WI   DWI   (region of
interest ; ROI)
3

.

Table 1
.   8   5   (2, 16, 18, 20, 24   )
T1WI/T2WI/DWI   / /   , 3
(38, 45, 63   )   / /   (Fig. 1),
10   / /   (Fig. 2),
7   / /   (Fig. 3),

Table 1. Qualitative Evaluation of the Hemorrhagic Cerebral Lesions according to Time Interval

		Signal Intensity		
	Number	T1WI[†]	T2WI[‡]	DWI*
Acute (< 24hrs)	5	iso- or high	high	high
(> 24hrs)	3	low	low	low
Early subacute	10	high	low	low
Late subacute	7	high	high	high
Early chronic	4	high	mixed	mixed
Late chronic	5	low	high	low
Total	34			

*: Diffusion weighted image
[†] : T1 weighted image
[‡] : T2 weighted image

Table 2. Mean Signal Intensity Ratio of the Hemorrhagic Cerebral Lesions according to Time Interval

		Signal Intensity Ratio (mean± SD[§])		
	Number	T1WI[†]	T2WI[‡]	DWI*
Acute (< 24hrs)	5	1.42± 0.78	2.58± 0.84	1.35± 0.08
(> 24hrs)	3	0.94± 0.18	0.63± 0.16	0.27± 0.10
Early subacute	10	1.35± 0.01	0.97± 0.21	0.86± 0.22
Late subacute	7	1.58± 0.04	1.54± 0.09	1.44± 0.14
Early chronic	4	1.26± 0.11	1.06± 0.14	0.97± 0.12
Late chronic	5	0.65± 0.23	1.51± 0.12	0.23± 0.18
Total	34			

*: Diffusion weighted image
[†] : T1 weighted image
[‡] : T2 weighted image
[§] : Standard deviation

2

. ± 0.12/0.23± 0.18 (Table 2, Fig. 5).

4 / / , 5
/ / (Fig. 4).

-
(mean signal intensity ratio ; SIR) T1WI DWI
5 T1WI/T2WI/DWI
1.42± 0.78/2.58± 0.84/1.35± 0.08, 3 0.94±
0.18/0.63± 0.16/0.27± 0.10, 1.35± (7, 8).
0.01/0.97± 0.21/0.86± 0.22, 1.58± 0.04 MRI
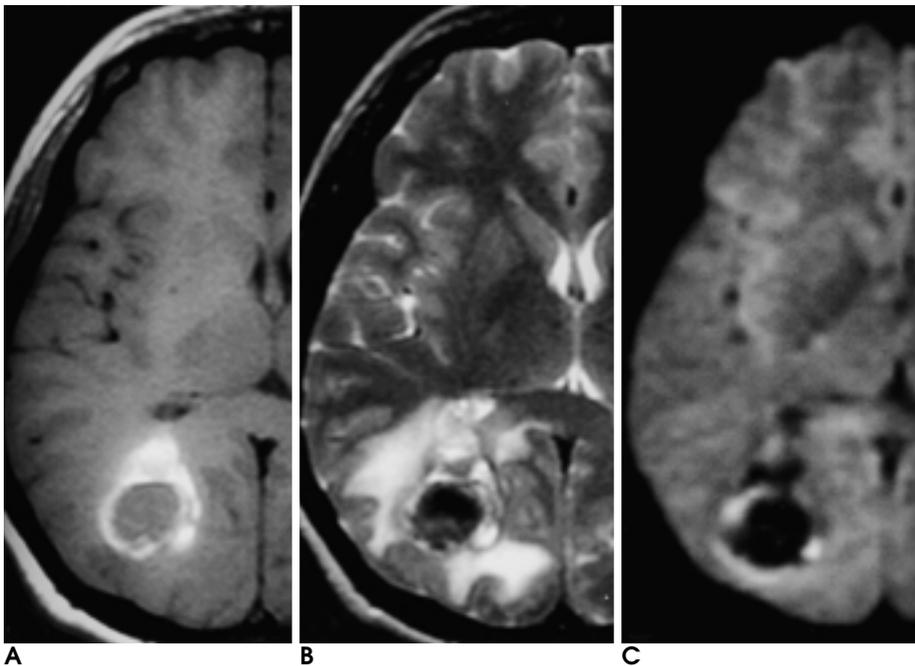/1.54± 0.09/1.44± 0.14, 1.26± 0.11/ 1.06±
0.14/0.97± 0.12, 0.65± 2.23/ 1.51 . MR

Fig. 1. A 44-year-old woman with spontaneous intracerebral hemorrhage in right occipital lobe. MR scans were obtained 38 hours after symptom onset.
A. Axial T1 weighted image shows central low and peripheral high signal intensity lesion.
B. Axial T2 weighted image shows central low and peripheral high signal intensity lesions with markedly perilesional edema.
C. Diffusion weighted image shows central low and peripheral high signal intensity.
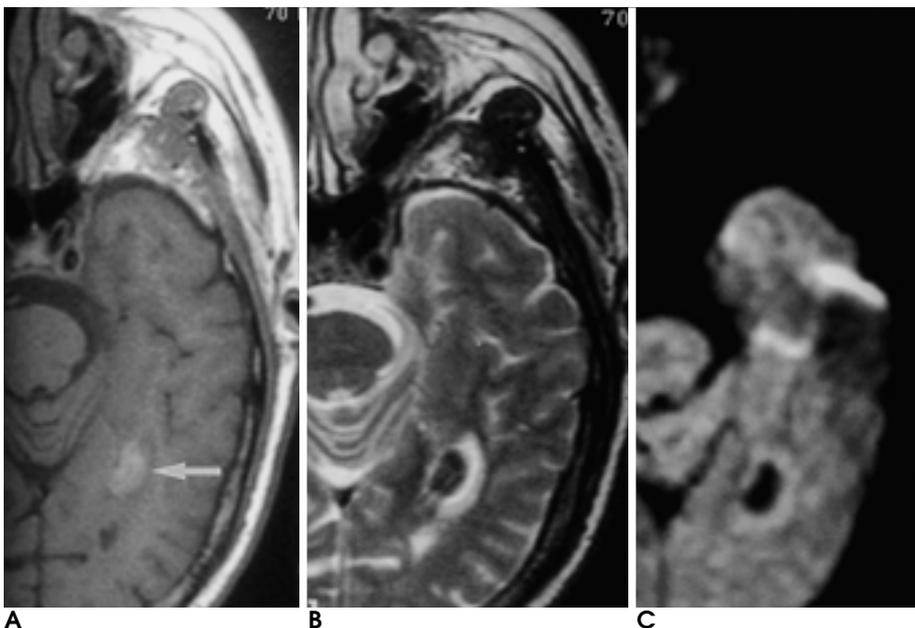
Fig. 2. A 50-year-old man with spontaneous intracerebral hemorrhage in left temporooccipital lobe. MR scans obtained 5 days after symptom onset.
A. Axial T1 weighted image shows high signal intensity lesion(arrow) surrounding low signal intensity area.
B. Axial T2 weighted image shows elongated low signal intensity surrounded by peripheral high signal intensity rim.
C. Diffusion weighted image shows central low signal intensity and peripheral high signal intensity lesion.
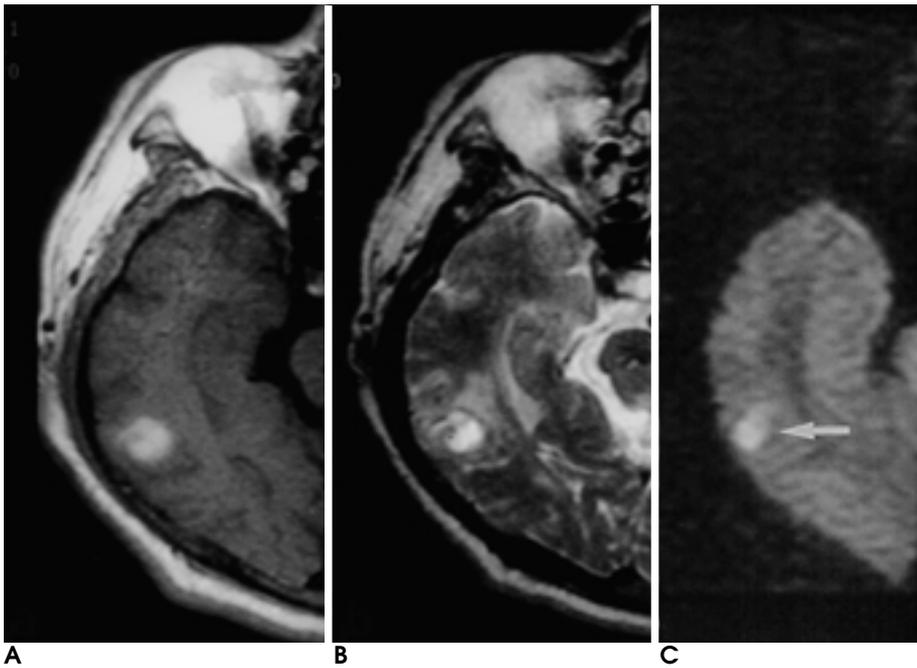
Fig. 3. A 51-year-old man with spontaneous intracerebral hemorrhage in right temporal lobe. MR scans obtained 3 weeks after symptom onset.
A. Axial T1 weighted image shows high signal intensity lesion surrounding low signal intensity rim.
B. Axial T2 weighted image shows high signal intensity lesion surrounded by peripheral low signal intensity rim.
C. Diffusion weighted image shows central high signal intensity(arrow) and peripheral low signal intensity.

A　　　　　　　　　　B　　　　　　　　　　C
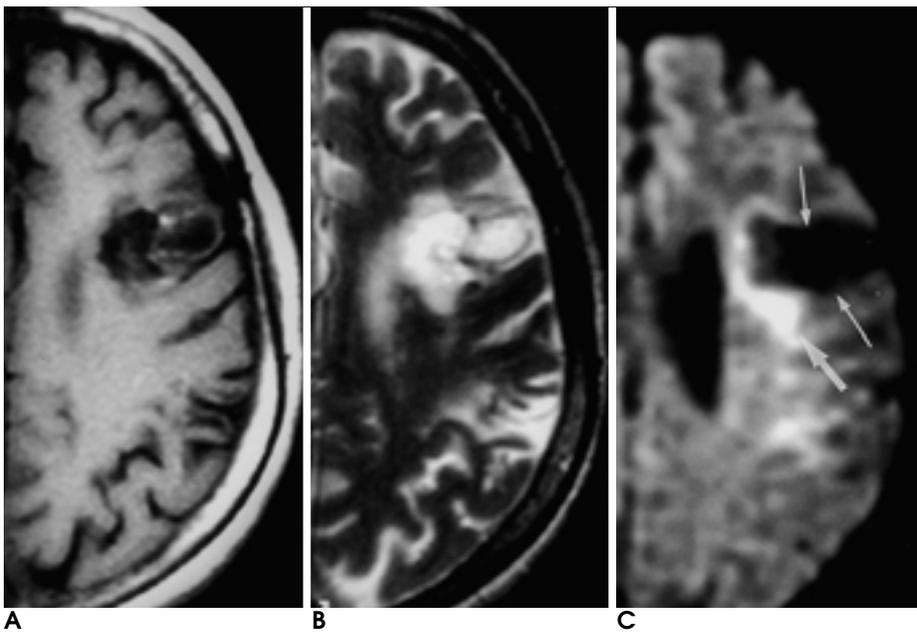
Fig. 4. A 63-year-old man with hemorragic infarction in left frontal lobe. MR scans obtained 4 months after symptom onset.
A. T1 weighted image shows low signal intensity lesion surrounding high signal intensity rim.
B. T2 weighted image shows high signal intensity surrounded by peripheral low signal intensity rim.
C. Diffusion weighted image shows central low signal intensity lesion(thin arrows) with development of new infarction(thick arrow) in medial side.

A　　　　　　　　　　B　　　　　　　　　　C

ADC) 　　　　　　　　.

. 　　　　　　　　　　　　　　　　　　　.

　　　　　　　methemoglobin 　　　　　.

　　　　　　　　　methemoglobin 　　　　　　　　　　(10).

(9). Atals (9) 　　　　　DWI data 　　　　　　　　　　　, 　　24

　　　　　　　, 　　　　　　　　　　　　　　　(11- 14).

(paramagnetic effect)

. 　　　　　　　　　　　　(oxyhemoglobin)
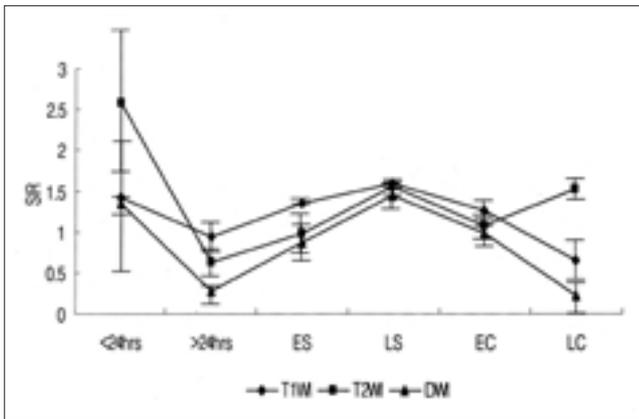
(apparent diffusion coefficient, 　　　. 　　　　　T2WI

4

Fig. 5. Mean signal intensity ratio of T1, T2 and diffusion weighted image in the hemorrhagic cerebral lesions(ES : Early subacute, LS : Late subacute, EC : Early chronic, LC : Late chronic). Except late chronic phase, SIR of DWI is reflective that of T2WI.

24

MRI   CT

(13).   GRE
FLAIR   (6).

DWI   Ebisu   (15)
24

.   van der Veen   (16)

DWI   .
24   T2WI   , DWI
.

24
deoxyhemoglobin
T2   T1WI   ,
T2WI   (13).

T2WI

(9, 11).
3   T2WI   DWI
.   T1WI

.

MRI
methemoglobin   , T1
T1WI   .   T2WI

T2WI

T2WI   (13,
17).

Bradley(13)   T2

DWI   T2 shine-
through   .   DWI
24

. Atlas   (9)
DWI

.

7   DWI   .

T1
T2WI   .   T1
T2WI   DWI
.

DWI   T2WI
T2WI   .

,

.

.

.

,   ADC   ADC
.

ADC
(18).

,

.   ,

.   ,

.

DWI   T2WI

DWI

DWI

.

1. Warach S, Gaa J, Siewert B, Wielopolski P, Edelman RR. Acute hu-
man stroke studied by whole brain echo planar diffusion weighted
magnetic resonance imaging. *Ann Neurol* 1995;37:231-241
2. Sorensen AG, Buonanno FS, Gonzalez RG, et al. Hyperacute
stroke: evaluation with combined multisectio diffusion weighted
and hemodynamically weighted echoplanar MR imaging.
Radiology 1996;199:391-401
3. Yuh WT, Crain MR, Loes DJ, Greene GM, Ryals TJ, Sata Y. MR
imaging cerebral ischemia: findings in the first 24hours. *AJNR Am*

J Neuroradiol 1991;12:621-629

4. Bradley WG. MR appearance hemorrhage in the brain. *Radiology* 1993;189:15-26

5. Zimmerman RD, Heier LA, Snow RB, Liu DPC, Kelly AB, Deck MDF. Acute intracranial hemorrhage: intensity changes on sequential MR scans at 0.5T. *AJNR Am J Neuroradiol* 1998;9:47-57

6. Lin DD, Filippi CG, Steever AB, Zimmerman RD. Detection of intracranial hemorrhage: comparison between gradient-echo images and b0 images obtained from diffusion-weighted echo-planar sequences. *AJNR Am J Neuroradiol* 2001;22:1275-1281

7. Benveniste H, Hedlund LW, Johnson GA. Mechanism of detection of acute cerebral ischemia in rats by diffusion-weighted magnetic microscopy. *Stroke* 1992;23:746-754

8. Unger E, Littlefield J, Gado M. Water content and water structure in CT and MR signal changes: possible influence on detection of acute stroke. *AJNR Am J Neuroradiol* 1988;9:687-691

9. Atlas SW, DuBois P, Singer MB, Lu D. Diffusion measurements in intracranial hematomas: implications for MR imaging of acute stroke. *AJNR Am J Neuroradiol* 2000;21:1190-1194

10. Fischbein NJ, Roberts TP, Dillon WP. Bleed or stroke? diffusion measurements in intracranial hematomas. *AJNR Am J Neuroradiol* 2000 ;21:1179-1180

11. Gomori JM, Grossman RI, Goldberg HI, Zimmerman RA, Bilaniuk LT. Intracranial hematoma: imaging by high field MR. *Radiology* 1985;157:87-93

12. Weigarten K, Zimmerman RD, Deo-Narine V, et al. MR imaging of acute intracranial hemorrhage: findings on sequential spin-echo images in a dog model. *AJNR Am J Neuroradiol* 1991;12:457-467

13. Bradley WG Jr. MR appearance of hemorrhage in the brain. *Radiology* 1993;189:15-26

14. Linfante I, Llinas RH, Caplan LR, Warach S. MRI features of intracerebral hemorrhage within 2 hours from symptom onset. *Stroke* 1999;30:2263-2267

15. Ebisu T, Tanaka C, Umeda M, et al. Hemorrhagic and nonhemorrhagic stroke: diagnosis with diffusion-weighted and T2-weighted echo-planar MR imaging. *Radiology* 1997;203:823-828

16. van der Veen JW, van Gelderen P, Creyghton JH, Bovee WM. Diffusion in red blood cell suspensions: separation of the intracellular and extracellular NMR sodium signal. *Magn Reson Med* 1993; 29:571-574

17. Janick PA, Hackney DB, Grossman RI, Asakura T. MR imaging of various oxidation states of intracelluar and extracelluar hemoglobin. *AJNR Am J Neuroradiol* 1991;12:891-897

18. Tong DC, Adami A, Moseley ME, Marks MP. Relationship between apparent diffusion coefficient and subsequent hemorrhagic transformation following acute ischemic stroke. *Stroke* 2000;31: 2378-2384

Diffusion Weighted MR Image of Intracranial Hemorrhage[1]

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Purpose: To determine changes in the signal intensity of intracerebral hemorrhagic lesions according to the time interval, between the onset of symptoms and MR imaging in the T1-weighted (T1W1), T2-weighted (T2W1) and diffusion-weighted modes.

Materials and Methods: Thirty-four patients with hemorrhagic stroke who underwent DWI and conventional MRI were involved in this study. Hemorrhagic phase was determined according to the time interval between the onset of symptoms and MR scanning, and was as follows: acute (3 days or less): eight patients); early subacute (7 days or less): ten patients; late subacute (4 weeks or less): seven patients; early chronic (3 months or less) : four patients); and late chronic (more than 3 months): five patients. Using a 1.5T MR imager and the single-shot echo-planar imaging technique, T1-weighted, fast spin-echo T2-weighted, and diffusion-weighted were obtained. In all cases qualitative signal intensity (SI) at the center of a lesion was recorded, and the ratio between this and normal brain parenchyma was calculated.

Results: SI at the center of a lesion was found to be iso or high/high/high (T1WI/T2WI/DWI) in five of eight acute-phase cases (interval of 24 hours or less) and low/low/low in the remaining three (interval of 72 hours or less). Other signal intensities were as follows: early subacute phase: high/low/low (all ten cases); late subacute phase: high/high/high (all seven cases); early chronic phase: high/high/high (all four cases); late chronic phase: low/high/low (all five cases). Mean SIRs were as follows: in the five acute-phase cases in which SI was iso or high: $1.42\pm 0.78 / 2.58\pm 0.84 / 1.35\pm 0.08$ (T1WI / T2WI / DWI); in the remaining three acute-phase cases: $0.94 \pm 0.18 / 0.63\pm 0.16 / 0.27\pm 0.10$; in the early subacute phase, $1.35\pm 0.01 / 0.97\pm 0.21 / 0.86\pm 0.22$ in early subacute phase, $1.58\pm 0.04 / 1.54\pm 0.09 / 1.44\pm 0.14$; in the early chronic phase: $1.26\pm 0.11 / 1.06\pm 0.14 / 0.97\pm 0.12$; and in the late chronic phase: $0.65\pm 2.23 / 1.51\pm 0.12 / 0.23\pm 0.18$.

Conclusion: The DWI findings of intracerebral hemorrhage reflect the findings of T2WI. When interpreting the DWI findings in patients with intracerebral hemorrhage, an understanding of the temporal evolution of this is very helpful .

Index words : Brain, MR
Brain, diffusion
Brain, infarction
Brain, hemorrhage

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