

가

1

: (Magnetic Resonance Spectroscopy: MRS)

MRS

가

:

가

15

,

21

가

(Magnetic Resonance Imaging: MRI) MRS

. MRI

, MRS

(MR spectrum)

: 가

MRI

(30 ,

1 , 2 , 3) MRS

3

N-Acetyl

Aspartate(NAA), Myoinositol(ml)

, Lactate(Lac) -

Glutamine/Glutamate(-Glx)

30

가가

3

가

MRI

(3, 24, 48, 72)

Cho, ml, -Glx

, Lac

, -Glx

가

, NAA

: MRS

,

.

(stroke)

MRI

12

가

CT

MRI

(thrombolysis)

(angioplasty)

(6).

가

3

가

(1).

가

3-6

(magnetic resonance spectroscopy: MRS)

가

(7-13). MRS

(ischemic penumbra)

CT MRI

(2).

(computed tomography: CT)

(magnetic resonance imaging: MRI)

(3-5). CT

24

‘

“

가

”

가

MRS

가

(14-17).

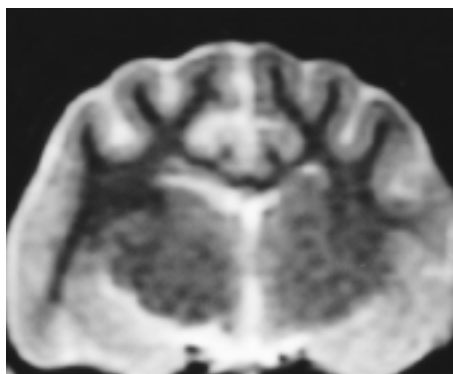
T2

(T2-weighted image: T2WI)

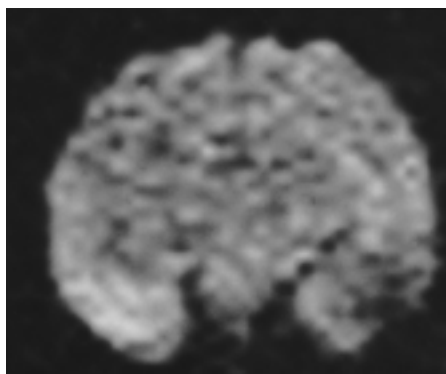
1998 12 29

1999 6 17

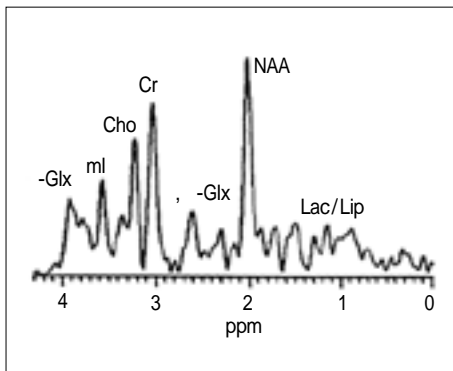
(diffusion-weighted image: DWI)
MRS 가
가 3
72
MRS
가 MRS
(Siemens, Erlangen, Germany)
(Histoacryl , B. Braun Surgical GmbH, Melsungen, Germany) 0.5 cc
(Terbal 150 , Balt, Montmorency, France) 0.2g
(Lipiodol , AMM306, Guerbet, Bois, France) 2.5cc 가
1:5
가 15 (4-5Kg, =4.4 Kg)
가 (Keta- mine , dl-2-(O-chlorophenyl)-2-(methylamino) Cyclo-hexanone hydrochloride, Yuhan, Seoul, Korea) 3.5ml (Rompun , Xylazine hydrochloride, Bayer Korea, Seoul, Korea) 0.5ml
가



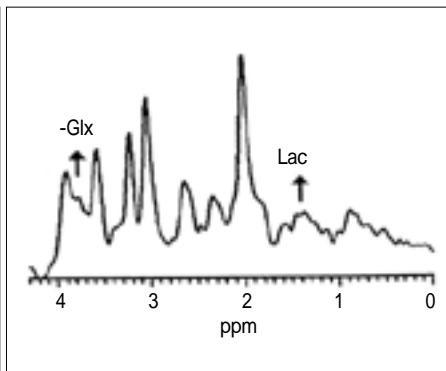
A



B



C



D

Fig. 1. MR images and MR spectra of a cat with thirty-minute-old infarct in the right cerebral hemisphere. A. T2-weighted image shows no abnormal high signal intensity. B. Diffusion-weighted image shows no abnormal bright signal intensity. C. MR spectrum obtained from the contralateral normal region. D. MR spectrum obtained from the infarcted region shows elevation of Lac/Cr and -Glx/Cr.

(MRI)
T1 (T1 weighted image : T1WI) T2WI DWI
1.5T Signa Horizon MR Scanner(GE
Medical Systems, Milwaukee, U.S.A.)

(extremity linear coil)
(sagittal), (coronal) (axial) 가
15 가
(30 , 1 , 2 , 3)
T1WI (TR/TE = 500 msec/10 msec) T2WI (TR/
TE = 3200ms/102ms) 256 × 192matrix, 5mm , 2mm gap
DWI (TR/TE = 10,000/100msec, 128 × 128matrix,
5mm , b-value = 1,000sec/mm²)

(MRS)
T2WI DWI MRS (volume
of interest: VOI)
(voxel volume) 3.4 cm³ (1.5 cm ×
1.5 cm × 1.5 cm)
MR spec-

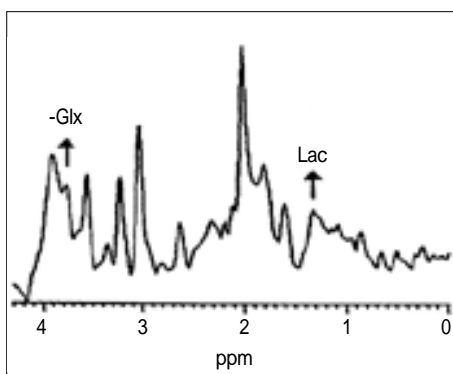


Fig. 2. MR spectra of a cat with one-hour-old infarct in the right cerebral hemisphere. MR spectrum obtained from the infarcted region shows elevation of Lac/Cr and -Glx/Cr.

MR spectrum
MRS
, STEAM (Stimulated Echo Acquisition Mode,
TR/TE/TM = 3000ms /30 ms/14 ms)
MR spectrum
(time to echo:
TE), 30ms 가 15
30 , 1 , 2 , 3 MR spectrum
, 128 CHES
H₂O
MR spectrum
' SAGE ' (G.E. Medical Systems, Milwaukee,
U.S.A.) MR spectrum . MR spec-
trum (resolution) (signal-to-
noise ratio: SNR) 가 zero-filling
Gaussian/Lotenzian filtering Fourier
Transformation(FT) MR spectrum

T2WI DWI
MRS 6 , N-
Acetyl Aspartate(NAA), Creatine(Cr), Choline(Cho), -
Glutamine/Glutamate(-Glx) , -Glutamine/Glutamate
(, -Glx), Myoinositol(ml), Lactate(Lac) (identifica-
tion)
(quantitation) , Cr

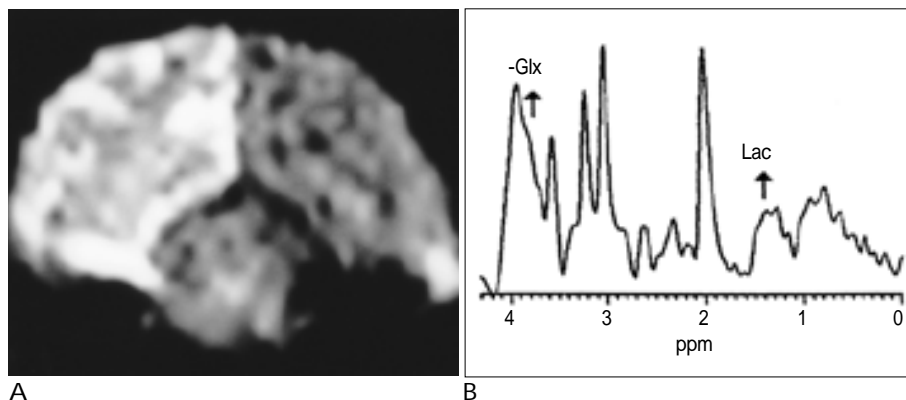


Fig. 3. MR images and MR spectra of a cat with two-hour-old infarct in the right cerebral hemisphere. A. Diffusion-weighted image demonstrates the increased signal intensity in the right cerebral hemisphere. B. MR spectrum obtained from the infarcted region shows elevation of Lac/Cr and -Glx/Cr.

(MRI)
T1WI T2WI DWI
MR Scanner
가
MRI (3, 24, 48,
72) T1WI (TR/TE = 500 msec/10 msec), T2WI
(TR/TE = 3200 ms/102 ms, 256 × 192 matrix, 5 mm , 2 mm
gap) DWI (TR/TE = 10,000/100 msec, 128 × 128 matrix,
5 mm , b-value = 1,000 sec/mm²)
(MRS)
T2WI DWI MRS (volume of interest:
VOI)
8 cm³ (2 cm × 2 cm × 2 cm)
voxel MRS
MRS
STEAM
(3, 18, 48, 72
) MR spectrum
MRS

(MRI)
30 T2WI 15
(60%)
1 T2WI 15
(100%)
T2WI 15
, DWI 15
(100%)
T2WI 15
, DWI 15
(100%)
3 T2WI

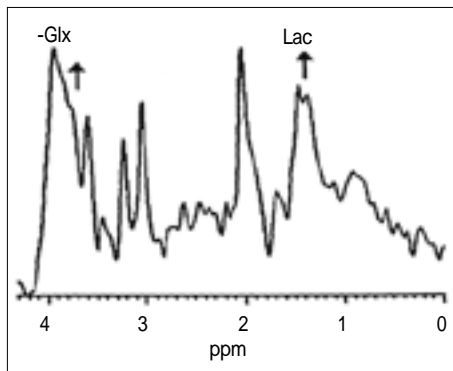


Fig. 4. MR images and MR spectra of a cat with three-hour-old infarct in the right cerebral hemisphere. MR spectrum obtained from the infarcted region shows elevation of Lac/Cr and -Glx/Cr.

15
15 (100%)
(MRS)
MR
spectrum 6가
NAA(2.02ppm), Cr(3.0ppm), Cho(3.2ppm), ml(3.6ppm),
Lac(1.3ppm), -Glx(2.2-2.5ppm), , -Glx(3.6-3.8ppm) MR
spectrum , Table 1
Cr
(Fig. 1-6 and Table 1). Lac -
Glx 30 가 3
가
가
MRI MRS
(MRI)
3 T2WI 2
, DWI 2 (100%)
. 24
T2WI 11 7 (64%)
가
, 4 (36%)

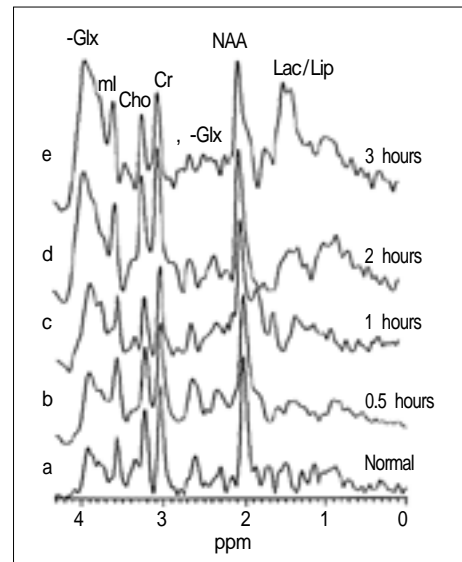


Fig. 5. Proton MR spectra recorded at 30 minutes, 1 hour, 2 hours, and 3 hours after induction of infarction in cat brains. a. A typical proton MR spectrum obtained from the normal region of a cat brain. b-e. Proton MR spectra corresponding to the various times after induction of infarction.

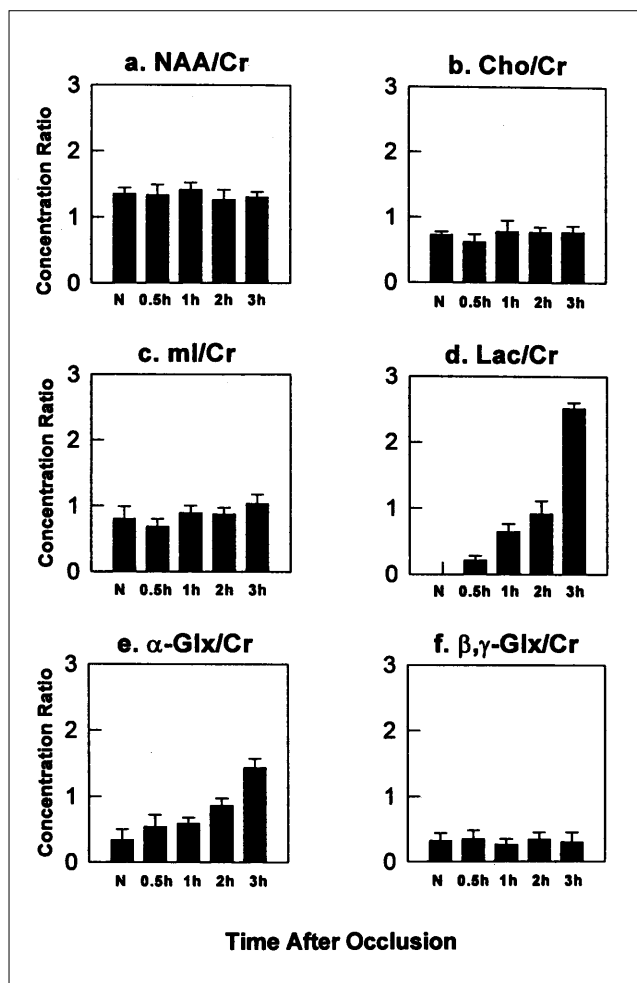


Fig. 6. Bar graphs showing the concentration ratios of cerebral metabolites measured at the various times after the onset of the right common carotid artery occlusion in cats.

Table 1. Time Course Variation of the Concentration Ratios of Cerebral Metabolites in Cerebral Infarctions of Cats

	NAA/Cr	Cho/Cr	mI/Cr	Lac/Cr	-Glx/Cr	, -Glx/Cr
Normal	1.35 ± 0.09	0.73 ± 0.05	0.80 ± 0.19	-	0.34 ± 0.16	0.32 ± 0.12
30 mins	1.33 ± 0.16	0.62 ± 0.12	0.68 ± 0.12	0.21 ± 0.07	0.54 ± 0.18	0.35 ± 0.13
1 hr	1.41 ± 0.11	0.78 ± 0.17	0.89 ± 0.11	0.64 ± 0.12	0.59 ± 0.09	0.26 ± 0.09
2 hrs	1.26 ± 0.15	0.77 ± 0.08	0.87 ± 0.10	0.91 ± 0.20	0.86 ± 0.11	0.34 ± 0.11
3 hrs	1.30 ± 0.08	0.77 ± 0.10	1.03 ± 0.14	2.51 ± 0.09	1.43 ± 0.14	0.30 ± 0.15

Note that the Cr peak was used as an internal standard to normalize the intensities of metabolites of interest. The concentration ratio values are mean ± standard deviation.

Table 2. Time Course Variation of the Concentration Ratios of Cerebral Metabolites in Human Cerebral Infarctions

	NAA/Cr	Cho/Cr	mI/Cr	Lac/Cr	-Glx/Cr	, -Glx/Cr
Normal	1.97 ± 0.12	0.88 ± 0.12	0.39 ± 0.18	-	0.35 ± 0.19	0.20 ± 0.12
3 hrs	1.31 ± 0.21	0.85 ± 0.24	0.29 ± 0.12	1.25 ± 0.15	0.31 ± 0.22	0.29 ± 0.15
24 hrs	1.32 ± 0.33	0.95 ± 0.27	0.48 ± 0.11	2.26 ± 0.49	0.35 ± 0.07	0.32 ± 0.27
48 hrs	2.05 ± 0.51	1.72 ± 0.35	0.84 ± 0.10	13.5 ± 2.75	1.08 ± 0.15	1.19 ± 0.31
72 hrs	0.73 ± 0.23	1.33 ± 0.14	0.38 ± 0.20	14.9 ± 3.89	0.38 ± 0.09	1.01 ± 0.24

Note that the Cr peak was used as an internal standard to normalize the intensities of metabolites of interest. The concentration ratio values are mean ± standard deviation.

DWI 11 (100%)
WI 6 (100%)
2 (100%)
(MRS)
Table 2
(Fig. 7-10 and Table 2).
Lac, -Glx 3 가
72 가
3 72 가
(thrombolytic therapy)
가
가
가
6
가
가

CT T2WI
(1). 가

DWI MRS 가

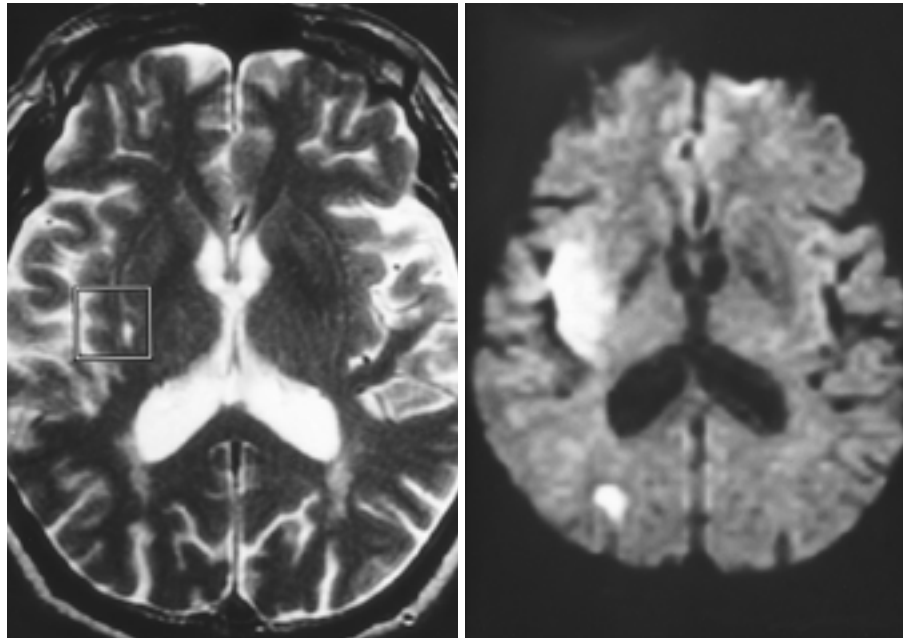


Fig. 7. MR images and MR spectra of the patient with three-hour-old cerebral infarct in the right temporal lobe. A. T2-weighted image shows no abnormal signal intensity. B. Diffusion-weighted image demonstrates the increased signal intensity in the right insular- and junctional-area of the right occipitoparietal region. C. MR spectrum obtained from the contralateral normal region. D. MR spectrum obtained from the infarcted region shows increase of Lac/Cr & , -Glx/Cr and decrease of NAA/Cr.

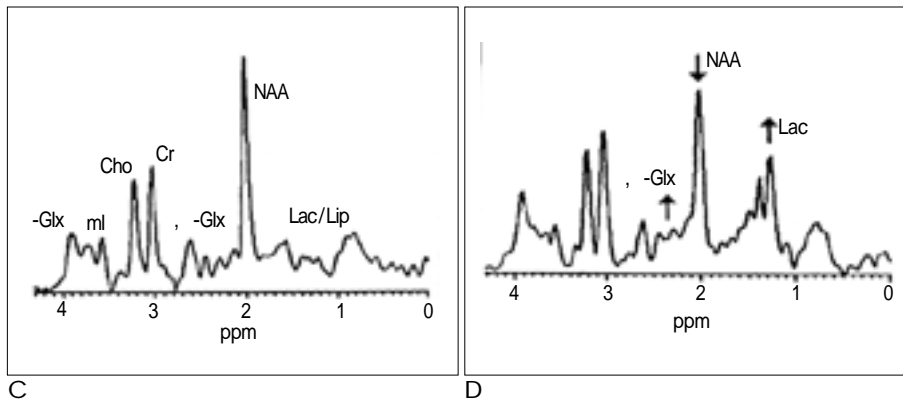


Fig. 8. MR images and MR spectra of the patient with 24-hour-old cerebral infarct in the right cerebellum. A. Diffusion-weighted image demonstrates the increased signal intensity in the right cerebellum. B. MR spectrum obtained from the infarcted region shows increase of Lac/Cr & , -Glx/Cr and decrease of NAA/Cr.

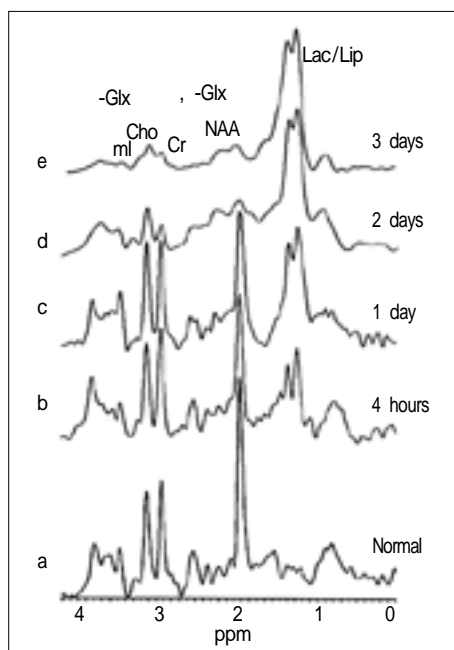


Fig. 9. Proton MR spectra recorded at 3, 24, 48 and 72 hours following the onset of infarction in humans.

a. A typical proton MR spectrum obtained from the normal region of human brains.

b-e. Proton MR spectra corresponding to the various times after the onset of infarction.

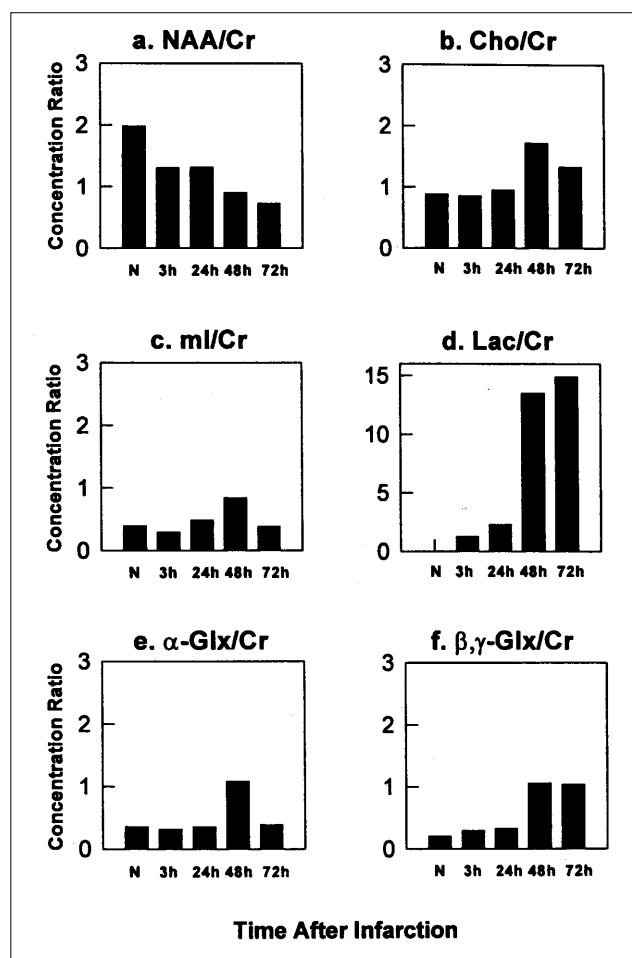


Fig. 10. Bar graphs showing the concentration ratios of cerebral metabolites measured at the various times after the onset of infarction in humans.

DWI

가가 (18).
가 MRS
30 3
MRS
NAA, Cho, ml, , -Glx
가 , Lac -Glx
30 3 가 , Lac
Lac 가 , -Glx
가 NAA
가
(19-21). , Lac가 가
Lac
(neuronal marker)
Glx 가
(excitatory neuro-
transmitter) glutamate가
21
MRS
3 72
30 -3
가
(12,13) Barker (18) Gardian
20ml/min/100g
Lac
(19-25).
NAA

가 , (lipid peroxidation)
 가 , NAA
 ,
 가
 3
 가
 , MRS
 Lac 가 , NAA, -Glx , -Glx
 가 MRS

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Usefulness of Proton MR Spectroscopy in Acute Cerebral Infarction : An Experimental and Clinical Study¹

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Purpose : To evaluate the usefulness of single-voxel localized proton MR spectroscopy(MRS) in monitoring changes in cerebral metabolites in cases of acute cerebral infarction.

Materials and Methods : In 15 cats with common carotid artery occlusion and 21 patients with acute cerebral infarction T2-weighted (T2WI), diffusion-weighted (DWI), and MR spectroscopic images were obtained at various times after stroke onset.

Results : In the cat model, Lac and -Glx levels increased as early as 30minutes after vascular occlusion and continued to increase for a further 2½ hours. The remaining metabolites, NAA, Cho, mI, and , -Glx, showed no significant change. During clinical study, increases in Lac and , -Glx, and decreases in NAA were detected three hours after stroke onset. These metabolites continued to change until 72 hours had elapsed. The remaining metabolites, Cho, mI, and -Glx tended to be constant.

Conclusion : MRS is capable of measuring and monitoring the metabolites involved in acute cerebral infarction. MRS may play an important role in the investigation of pathophysiology as well as in the early diagnosis of acute cerebral infarction.

Index words : Brain, infarction

Brain, MR

Magnetic resonance (MR), spectroscopy

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