

MR

:

1

1,2 .

.

2 .

3 .

4 .

4 .

5

: MR

MR

T1, T2

:

, 12

(n=2)

(3

, n=6)

(10

, n=4)

, 4.7 T MR

T1

10, 20, 30, 60, 90

T1

, T1, T2

MR

:

MR

가

10 ,

20

60

. T1

가

. T2

:

(CT),  
(MRI)

가

(scintigraphy),

, CT

가

CT

12

(1, 2).

가 가

, 12-24

가

, 24-48

(1).

, MR

1

2

3

4

5

NMR

1999 4 10

1999 12 6

12 ( : 2.7-4.0 kg, : 3.65 kg)  
(n=2) (n=10),

(3-5, n=6) (10-  
12, n=4)

5% halothane 15

2 liter/min N<sub>2</sub>O, O<sub>2</sub> 0.5% halothane

4 (Fig. 1).

MR  
1.4 cm, 1.8 cm

, MR

20 cm  
(artifact)

30 cm, 4.7

T MR (Biospec; Bruker, Fallanden, Switzerland)

MR

(static field homogeneity)  
(shimming) . MR (multislice),  
(multiecho) . 2 cm (axial)  
(FOV: field of view), 2 mm  
(number of average) 4, matrix  
128 × 256, 4

20 msec), MR T1 (TR/TE: 300/  
Schering, Berlin, Germany) Gadolinium DTPA (Magnevist,  
0.2 mmol/kg

가 10 cc

90 T1 10, 20, 30, 60,

KCl 20 ml 1 mol

10 % 16-24

10 cc

MR

T1 (TR/TE: 300/20 msec) T2  
(TR/TE: 3500/50 msec)

MR

(ROI) 69 pixel

가

$= p [1 - \exp(-TR/T1)] \times [\exp(-TE/T2)]$ , (p: proton density, TR: repetition time, TE: echo time)

T1 T1 T2

MR

1 12.5

1

MR

T1, T2

MR

가 A NOVA

student t-test, p-value

0.05

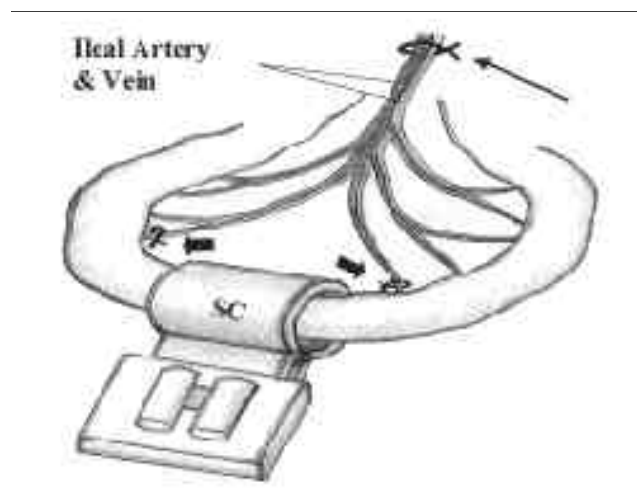
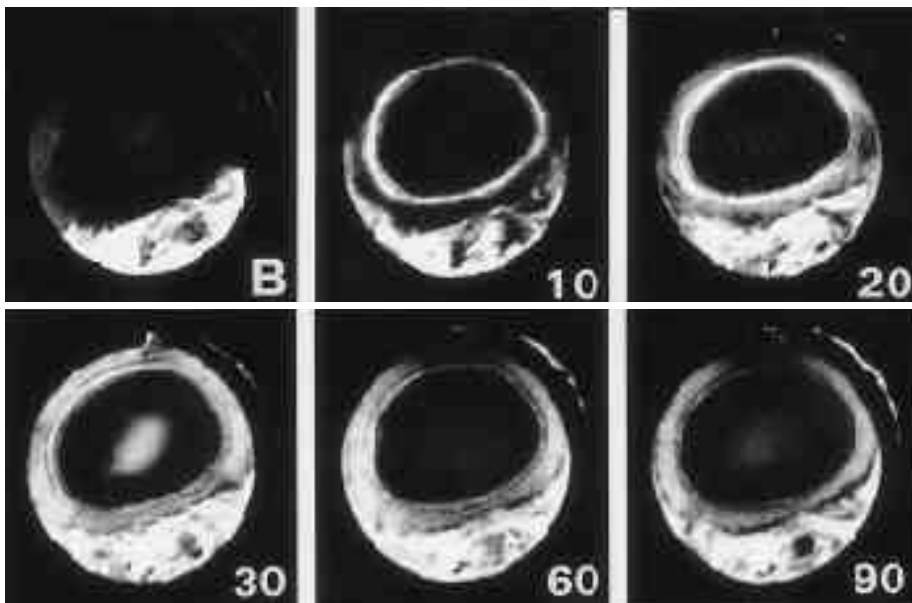
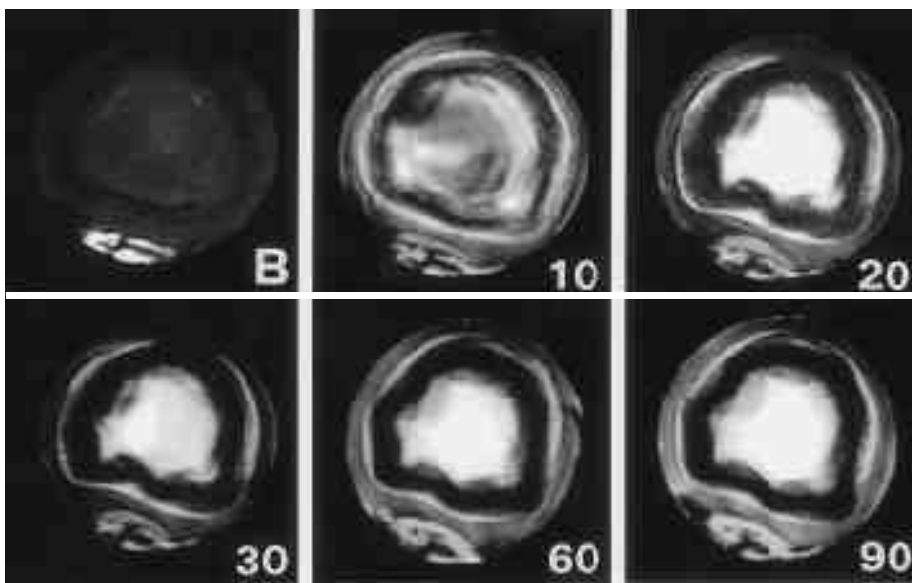


Fig. 1. Schematic diagram of bowel ischemia model. Bowel ischemia is induced by ligation of the proximal (long arrow) and distal (short arrows) ileal artery and vein. Columnar surface coil (SC) is applied on the expected ischemic bowel through the mesenteric fenestration.

[illegible]

**Fig. 2.A. A representative case of acute bowel ischemia. Contrast enhanced T1WI shows prominent submucosal enhancement, and demonstrates the peak enhancement at 20-minute after administration of contrast media.**

**B. A representative case of subacute bowel ischemia. Contrast enhanced T1WI shows gradual enhancement, and demonstrates delayed peak enhancement at 60-minute after administration of contrast media. (B: baseline non-enhanced image)**



ROI 가 , (p < 0.05), 가 가 1 (Table 2).

T1, T2 , (p < 0.05), (Table 1).

T1

T2

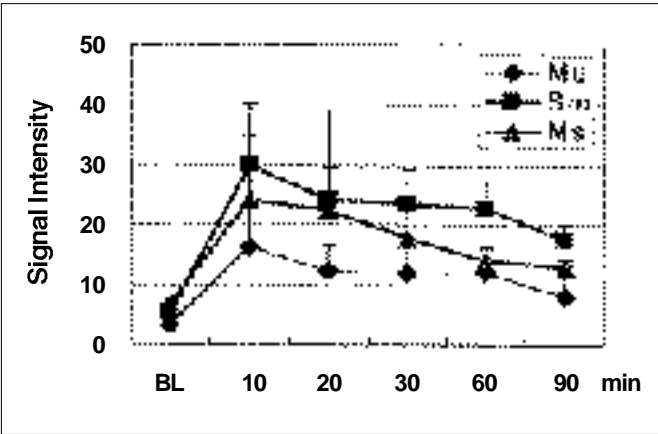
Table 1. Comparison of MR Signal Intensity between Acute and Subacute Bowel Ischemia

Bowel wall Layers	T1WI			T2WI		
	Normal	Acute	Subacute	Normal	Acute	Subacute
Mucosa	3.6±2.0	12.5±7.6	8.6±5.2	4.6±0.9	13.5±4.8	9.4±7.1
Submucosa	5.3±2.5	8.0±5.0	8.2±3.0	4.9±0.3*	9.3±2.9*†	5.2±1.4†
Muscle	6.8±0.1	10.2±6.6	11.0±3.2	5.2±0.6*‡	20.4±2.9*	15.5±8.1‡

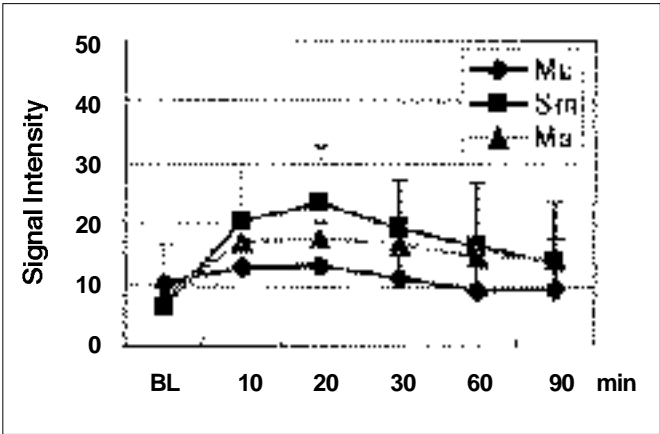
\*: Significant differences (p-value < 0.05) between normal control group and acute ischemic group  
†: Significant differences (p-value < 0.05) between acute ischemic group and subacute ischemic group  
‡: Significant differences (p-value < 0.05) between normal control group and subacute ischemic group

Table 2. Pathologic Findings of the Ischemic Bowel Wall

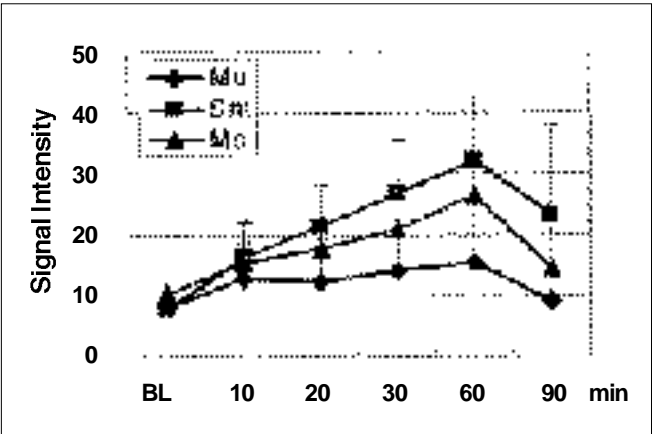
Pathologic Findings	Total (n= 10)	Acute (n= 6)	Subacute (n= 4)
Mucosa			
Congestion	8 (80%)	4 (67%)	4 (100%)
Inflammation	9 (90%)	6 (100%)	3 (75%)
Submucosa			
Congestion	5 (50%)	2 (33%)	3 (75%)
Edema	5 (50%)	3 (50%)	2 (50%)
Muscle			
Congestion	6 (60%)	4 (67%)	2 (50%)
Ischemia	8 (80%)	5 (83%)	3 (75%)



A



B



C

Fig. 3.A. Normal control group. Time-signal intensity curve shows early peak enhancement at 10-minute after administration of contrast media.  
B. Acute ischemic group. Time-signal intensity curve shows low enhancement and demonstrates peak enhancement at 20-minute after administration of contrast media.  
C. Subacute ischemic group. Time-signal intensity curve shows gradually increased signal intensity and demonstrates delayed peak enhancement at 60-minute after administration of contrast media. (BL: baseline non-enhanced image, Mu: mucosa, Sm: submucosa, Ms: muscle)



가

가

T2

가

가

CT

가 (13),

(14-19).

가

T2

T2

(20)

가

MR

(spectroscopy)

31P MR

ATP가

가 (21).

(even-echo rephasing)

가

(22),

(gradient re-

focusing)

MR

(23),

(phase contrast) cine MR

가 (24).

MR

가

가

MR

가

T2

가

MR

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## MR Findings of Bowel Ischemia with Mesenteric Vascular Occlusion : Comparison with Pathologic Findings in a Cat Model<sup>1</sup>

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**Purpose :** In order to determine the characteristic MR findings for the early diagnosis of bowel ischemia, we analysed the dynamic enhanced MR images of ischemic bowel induced by mesenteric vascular occlusion in a cat model, and compared the T1- and T2- weighted images (WI) of extracted bowel with the pathologic findings.

**Materials and Methods :** According to the ischemic period, twelve cats were assigned to either the normal control group (no ischemic period, n= 2), the acute ischemic group (ligation of mesenteric vessels for 3 hours, n= 6) or the subacute ischemic group (ligation of mesenteric vessels for 10 hours, n= 4). Under general anesthesia, laparotomy was performed. The ileal artery and vein were ligated, and a columnar surface coil was applied to the expected bowel ischemia. Using a 4.7 T MR scanner, contrast-enhanced T1WI were obtained, after bolus injection of contrast media, at 10, 20, 30, 60, and 90 minutes. After formalin fixation of the extracted bowel, T1- and T2WI were obtained, and the specimens were pathologically examined. MR signal intensity at each layer of the bowel wall was measured and compared with the histopathologic findings.

**Results :** On contrast enhanced MR images, the submucosal layer showed most intensive enhancement, followed in decreasing order of signal intensity- by muscle and mucosa. Time to peak enhancement of bowel wall was 10-minutes in the normal control group, and 20 and 60 minutes in the acute and subacute bowel ischemia groups, respectively. On T1WI, no significant differences in signal intensity were observed between the ischemic group and the normal control group. On T2WI, the signal intensity of the submucosal layer of the acute ischemic group was significantly higher than that of the normal control or subacute ischemic group, and the signal intensity of the muscular layer of the ischemic group was significantly higher than that of the normal control group.

**Conclusion :** Time to peak enhancement of bowel wall was a helpful criterion for assessment of the ischemic period. Analysis of the signal intensity of the bowel wall layer was useful for the early detection of bowel ischemia.

**Index words :** Intestines, ischemia

Magnetic Resonance (MR), experimental

Magnetic Resonance (MR), contrast enhancement

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