

: SPIO

1

.

: SPIO

: 51 (31, 20) 가 30 SPIO
 T1 (Fast low - angle shot, FLASH)
 T2 (turbo spin echo, TSE) . SPIO T1 FLASH
 T2 TSE
 (, CNR) . ,
 : SPIO T1 FLASH $73.0 \pm 22.1\%$ 가 ,
 $21.8 \pm 12.6\%$ 가 ($p < 0.05$), 40% 가
 96.8%, 100% . , T2 TSE $35.5 \pm$
 17.2%, $0.2 \pm 10.5\%$ ($p < 0.05$).
 CNR T1 FLASH 15.4 ± 6.0 4.7 ± 4.4 , T2
 TSE -2.6 ± 0.7 , 2.7 ± 4.4 ($p < 0.05$).
 T2
 TSE 가 ($p < 0.05$).
 : SPIO T1 FLASH 가 T2 TSE

(Superparamagnetic iron oxide, SPIO)

T2 (Kupffer) (reticuloendothelial sys- (characterization) (4 - 7).
 tem) , SPIO SPIO T1
 T2 (8 - 10).
 (1 - 3). (phagocytic SPIO T1 -
 macrophage) 가 , 가 (T1 - weighted Fast low - angle shot,
 SPIO T1 - weighted FLASH) T2 -
 , 가 (T2 - weighted turbo spin echo, T2 - weighted
 가 , TSE) ,
 가 가
 SPIO T2
 T2

30

15 31

32-73 (54) ,

가 10 , 가 5 15 20 (region of interest, ROI) ROI

46-70 (57 가 가 ROI

) , 2

(n = 2), 가

(n =

20), (phase encoding direction)

, 6 가

(n = 9) SPIO

(percentage of sig -

8 (n = 9),

7 (- FP) 가 (> 400 ng/ml),

(tumor staining)

CT (n = 11)

1.5 T

(Magnetom Vision; Siemens, Erlangen, Germany)

(phased array multi-coil)

T2-weighted TSE (TR/TE/echo train lengths =

2,100 - 4,500/90/5, 120 × 256, two signal acquired, a

192 × 256 matrix) T1-weighted FLASH

(TR/TE = 135/4, 80, 120 × 256, 1)

MR , SPIO

SPIO 5% 100 mL 10

mol/kg SPIO (Feridex; Advanced Magnetix, Cambridge, U.S.A.) 30

10 2 ml

4 ml 30-60

3 SPIO

SPIO

T1 -FLASH 가

paired student t-test . P 0.05

가

가 가(unac-

ceptable, 1), (poor, 2), (fair, 3), (good, 4),

(excellent, 5) 5 가

Wilcoxon signed

ranks test . P 0.05

가

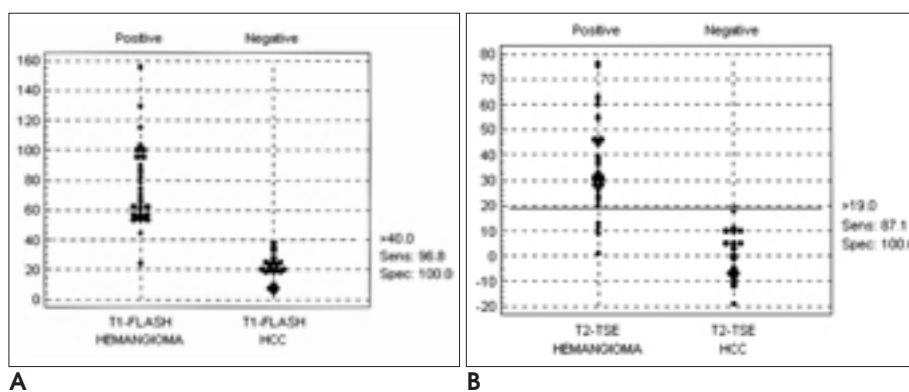


Fig. 1. Changes of signal intensity of hemangiomas and hepatocellular carcinoma on T1 weighted-FLASH (A) and T2 weighted- turbo spin echo (B) between before and after SPIO infusion.

A. Taking a signal increase of 40% on postcontrast T1-weighted FLASH as a cut-off value, sensitivity and specificity for hemangioma were 96.8% and 100% respectively.

B. Taking a signal decrease of 19% on postcontrast T2-weighted TSE as a cut-off value, sensitivity and specificity for hemangioma were 87.1% and 100% respectively.

(CNR: -6.0 ± 3.6), T2 - TSE
(CNR: 11.4 ± 5.5) (Table 1). SPIO
FLASH
(CNR: 9.4 ± 4.5), T2 TSE
가 CNR (CNR: 8.8 ± 5.4) (Fig. 2).
T1 FLASH 15.4 ± 6.0 가 CNR
($p < 0.05$), T2 TSE
 -2.6 ± 0.7
($p = 0.065$).
SPIO
, T1 FLASH
(CNR: -2.7 ± 3.8). T2 TSE

Table 1 . Value for the Liver-to-lesion Contrast-to-noise Ratio

	T1-FLASH	T2-TSE
Hemangioma (n=31)		
Pre-SPIO (A)	-6.0 ± 3.6	11.4 ± 5.5
Post-SPIO (B)	9.4 ± 4.3	8.8 ± 5.4
[B-A]	$15.4 \pm 0.7^+$	-2.6 ± 0.7
HCC (n=20)		
Pre-SPIO (A)	-2.7 ± 3.8	2.8 ± 4.8
Post-SPIO (B)	2.0 ± 1.4	5.5 ± 3.3
[B-A]	$4.7 \pm 2.4^{++}$	$2.7 \pm 4.4^{+++}$

Note. - Data are given as mean \pm standard deviation.

HCC = Hepatocellular carcinoma

SPIO = Superparamagnetic iron oxide

CNR = (SI of lesion - SI of normal liver parenchyme)/SI of noise

$^+$, $^{++}$, $^{+++}$: significant difference between pre- and post-SPIO
CNR ($p < .05$)

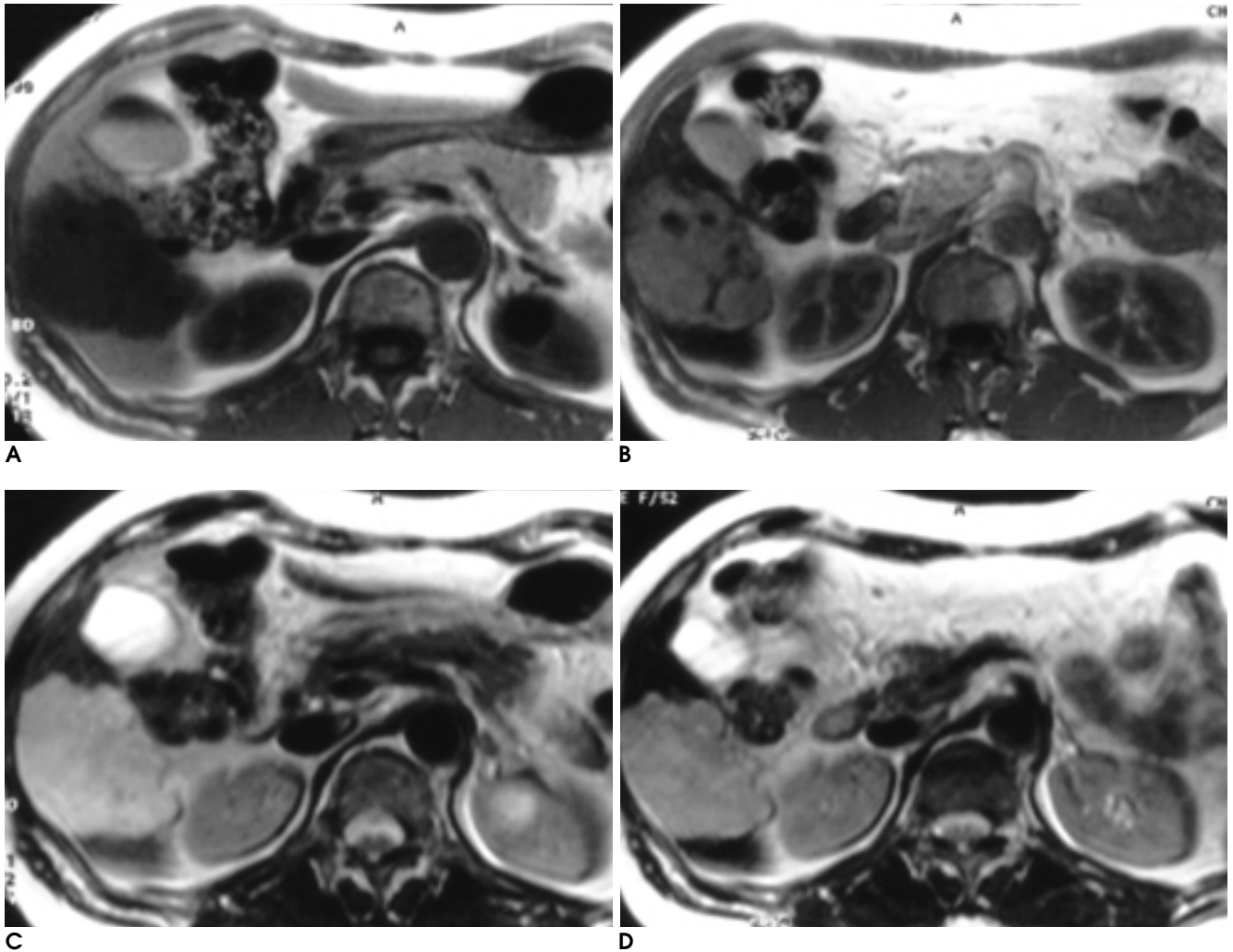


Fig. 2. 52-year-old woman with a hemangioma in segment 6.

A, B. On T1-weighted FLASH image (A), the hemangioma is hypointense relative to normal liver parenchyma. After SPIO enhancement (B), the lesion is enhanced significantly.

C, D. On T2-weighted TSE image, the signal intensity of hemangioma is much higher than normal hepatic parenchyma (C), which is low on SPIO enhancement (D).

16
1). SPIO T1 FLASH T2 TSE
(CNR: 2.8 ± 4.8) (Table
3.3) 가 (2.0 \pm 1.4 5.5 \pm
(Fig. 3), T1
T2 CNR 4.7 \pm 2.4
2.7 \pm 4.4 가 ($p < 0.05$).
SPIO T1 FLASH 73.0
 $\pm 22.1\%$ 가 21.8 \pm 12.6 %
가 . 40% 가
96.8%, 100% (Fig. 1).
, T2 TSE 35.5 \pm 17.2%
가 (Table 2). 19%
87.1%, 100%

Table 2. Value for signal intensity before and after SPIO and the percentage of signal intensity loss

	T1-FLASH	T2-TSE
Hemangioma (n=31)		
Pre-SPIO	331.3 \pm 75.3	712.6 \pm 226.3
Post-SPIO	573.2 \pm 187.0	459.5 \pm 217.3
PSIL	- 73.0 \pm 22.1*	35.5 \pm 17.2 **
HCC (n=20)		
Pre-SPIO	352.1 \pm 98.7	425.1 \pm 132.1
Post-SPIO	429.0 \pm 65.2	425.9 \pm 147.4
PSIL	- 21.8 \pm 10.6	0.2 \pm 10.5

Note. - Data are given as mean \pm standard deviation.

PSIL : percentage of signal intensity loss = [(SI enhanced - SI unenhanced)/SI unenhanced] \times (- 100)

*, **: significant difference with HCC patients ($p < .05$)

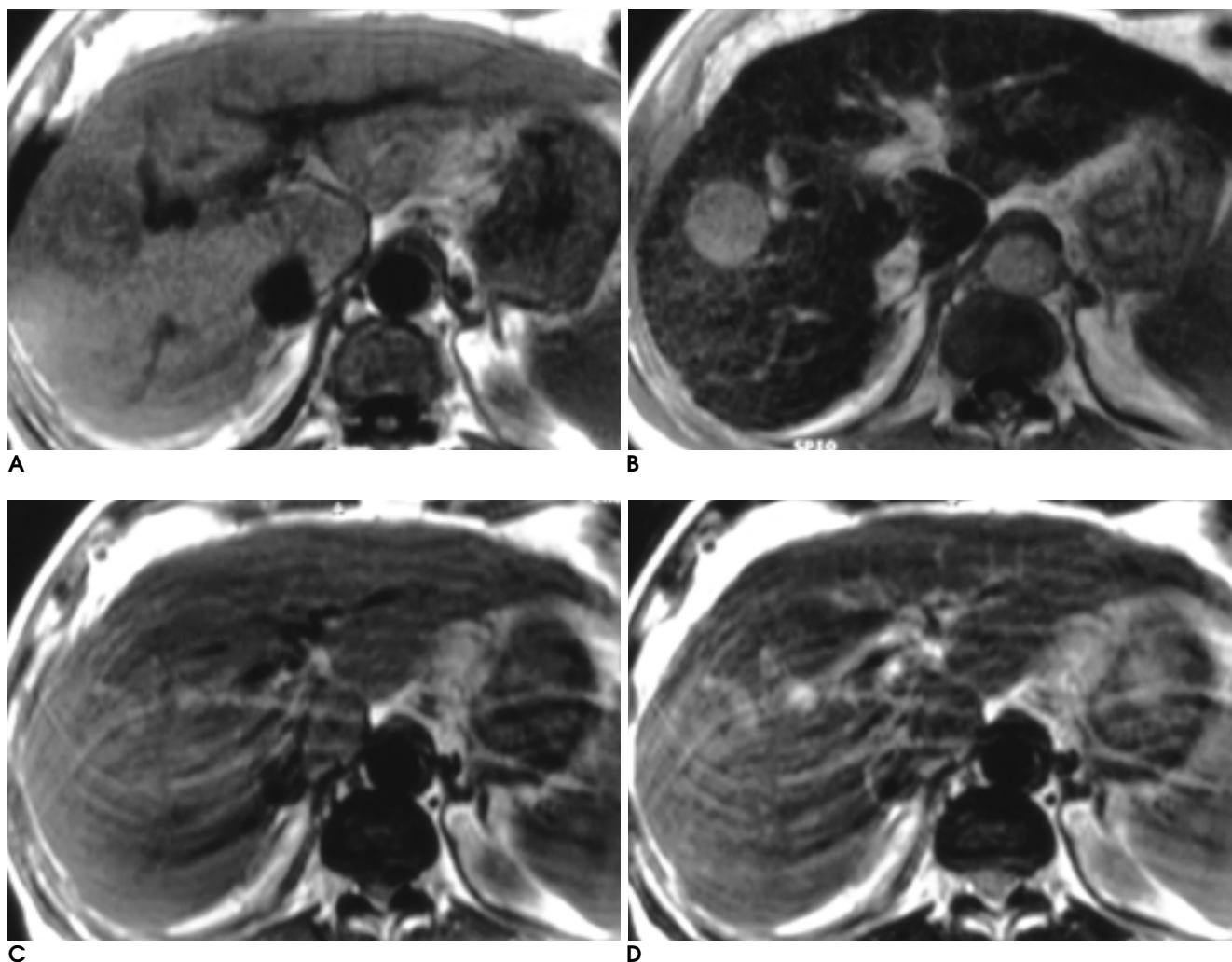


Fig. 3. 61-year-old man with HCC at segment 8.

A, B. On T1-weighted FLASH images (A), the hepatocellular carcinoma is hypointense to hepatic parenchyma. After SPIO infusion (B), the lesion show mild positive enhancement in the background of hypointense hepatic parenchyma.

C, D. T2-weighted TSE images obtained before (C) and after SPIO administration (D), show remarkably increased lesion to liver contrast due to negative enhancement of the hepatic parenchyma after SPIO infusion.

Table 3. Results of Qualitative Analysis of Lesion Conspicuity and Imaging Artifact

	Lesion Conspicuity	Imaging Artifact
HCC		
T2-Weighted TSE		
Pre-SPIO	3.45 ± 1.12	3.50 ± 0.69
Post-SPIO	4.36 ± 0.81 *	3.72 ± 0.62
T1-FLASH		
Pre-SPIO	3.45 ± 1.29	4.80 ± 0.50
Post-SPIO	3.18 ± 1.33	4.50 ± 0.50
Hemangioma		
T2-Weighted TSE		
Pre-SPIO	4.69 ± 0.47	4.00 ± 0.63
Post-SPIO	4.41 ± 0.78	4.09 ± 0.54
T1-FLASH		
Pre-SPIO	4.83 ± 0.47	4.91 ± 0.06
Post-SPIO	4.93 ± 0.37	4.82 ± 0.40

Note. - Data are given as mean ± standard deviation.

* : significant difference with unenhanced T2wTSE image ($p < .05$)

가 (Table 3). T1
FLASH 가 T2 TSE
($p > 0.05$),
T2 TSE
가 (P = 0.026) T1 FLASH
FLASH T2 TSE
, SPIO
($p > 0.05$).
0.4% - 7.3%
가
(11 -
13). , CT,
T2 “ ”
가
가
(11 - 13).
가 1.5 cm
MR SPIO
Kupffer
가 가 (1 - 3).

, SPIO 가
CTAP (CT arterial portography)
(2, 14 - 16). , Yamamoto
(17) SPIO 가
SPIO
T2 가
SPIO
(18 - 20). Christian (18) Urhahn
(19) T1 SPIO
가가 , Hahn (20) T2
SPIO
, T1
FLASH 73% 가 T2 TSE
36% 가
, T1 -
SPIO 가 T2 T1
T1 가
(21). SPIO T1 T2
(19 - 21), SPIO
T1 T1 가
, T1 가
, SPIO T2
(susceptibility)
T2*
T1
T2
가
(,)
SPIO T2 가
(20, 22). Wisse (22)
Kupffer
Hahn (20) T2
가 SPIO
SPIO 가
SPIO 가
T2 가
SPIO
가 가
SPIO 가가

가 가 (14-17).

2.7

T2

CNR

SPIO

가

(1-7),

T1

SPIO

가

, T2

가

가 가

가

T2 TSE
0 가
(Table 1).

T2

T1

가

T2

T1

FLASH

, T1

T1

가

case

SPIO

T1

FLASH

가

T2

TSE

, SPIO

CNR

가

T1

FLASH

T1

FLASH

T2

TSE

가

1. Fretz CJ, Elizondo G, Weissleder R, et al. Superparamagnetic iron oxide-enhanced MR imaging: pulse sequence optimization for detection of liver cancer. *Radiology* 1989;172:393-397
2. Tsang YM, Stark DD, Chen MC, Weissleder R, Wittenberg J, Ferrucci JT. Hepatic micrometastasis in the rat: ferrite-enhanced MR imaging. *Radiology* 1988;167:21-24
3. Saini S, Stark DD, Hahn PF, et al. Ferrite particles: a superparamagnetic MR contrast agent for enhanced detection of liver carcinoma. *Radiology* 1987;162:217-222
4. Weissleder R. Liver MR imaging with iron oxides: toward consensus and clinical practice. *Radiology* 1994;193:593-595
5. Ros PR, Freeny PC, Harms SE, et al. Hepatic MR imaging with ferumoxides: a multicenter clinical trial of the safety and efficacy in

the detection of focal hepatic lesions. *Radiology* 1995;196:481-488

6. Winter TC III, Freeny PC, Nghiem H, et al. MR imaging with i.v. superparamagnetic iron oxide: efficacy in the detection of focal hepatic lesions. *AJR Am J Roentgenol* 1993;161:1191-1198
7. Schwartz LH, Seltzer SE, Tempany CM, et al. Superparamagnetic iron oxide hepatic MR imaging: efficacy and safety using conventional and fast spin-echo pulse sequences. *J Magn Reson Imaging* 1995;5:566-570
8. van Gansbeke D, Metens TM, Matos C, et al. Effects of AMI-25 on liver vessels and tumors on T1-weighted turbo-field-echo images: implications for tumor characterization. *J Magn Reson Imaging* 1997;7:482-489
9. Poeckler-Schoeniger C, Koepke J, Gueckel F, Sturm J, Georgi M. MRI with superparamagnetic iron oxide: efficacy in the detection and characterization of focal hepatic lesions. *Magn Reson Imaging* 1999;17:383-392
10. Finazzo M, Midiri M, Gallo C, Bartolotta TV, Luca A. Focal liver lesions: a comparison between magnetic resonance under base conditions and after a superparamagnetic contrast medium. *Radiol Med (Torino)* 1998;95:599-607
11. Stark DD, Felder RC, Wittenberg J, et al. Magnetic resonance imaging of cavernous hemangioma of the liver: tissue-specific characterization. *AJR Am J Roentgenol* 1985;145:213-222
12. van Beers B, Demeure R, Pringot J, et al. Dynamic spin-echo imaging with Gd-DTPA: value in the differentiation of hepatic tumors. *AJR Am J Roentgenol* 1990;154:515-519
13. 1994;30:141-148
14. Fretz CJ, Stark DD, Metz CE, et al. Detection of hepatic metastasis: comparison of contrast-enhanced CT, unenhanced MR imaging, and iron-oxide-enhanced MR imaging. *AJR Am J Roentgenol* 1990;155:763-770
15. Stark DD, Weissleder R, Elizondo G, et al. Superparamagnetic iron oxide: clinical application as a contrast agent for MR imaging of the liver. *Radiology* 1988;168:297-301
16. Seneterre E, Taourel P, Bouvier Y, et al. Detection of hepatic metastasis: ferumoxides-enhanced MR imaging versus unenhanced MR imaging and CT during arterial portography. *Radiology* 1996;200:789-792
17. Yamamoto H, Yamashita Y, Yoshimatsu S, et al. Hepatocellular carcinoma in cirrhotic livers: detection with unenhanced and iron oxide-enhanced MR imaging. *Radiology* 1995;195:106-112
18. Grangier C, Tourniaire J, Mentha G, et al. Enhancement of liver hemangiomas on T1-weighted MR SE images by superparamagnetic iron oxide particles. *J Comput Assist Tomogr* 1994;18:888-896
19. Urhahn R, Adam G, Busch N, Chen JH, Euringer W, Gunther RW. Superparamagnetic iron oxide particles: what value has the T1 effect in the MR diagnosis of focal liver lesions. *Fortschr Röntgenstr* 1996;165:364-370
20. Hahn PF, Stark DD, Weissleder R, Elizondo G, Saini S, Ferrucci JT. Clinical application of superparamagnetic iron oxide to MR imaging of tissue perfusion in vascular liver tumors. *Radiology* 1990;174:361-366
21. Chambon C, Clement O, Le blanche a, Schouman-Claeys E, Fria G. Superparamagnetic iron oxides as positive MR contrast agents: in vitro and in vivo evidence. *Magn Reson Imaging* 1993;11:509-519
22. Wisse E, Doucet D, Van Bassuyt H. A transmission electron microscopic study on the uptake of AMI-25 by sinusoidal cells. In: Wisse E, Knook DL, McCuskey RS, Ed, *Cells of the hepatic sinusoid*, vol 3. Leiden: Kupffer cell Foundation, 1991:534-539

Hemangioma and Hepatocellular Carcinoma: Distinction with Superparamagnetic Iron Oxide-Enhanced MR Imaging¹

Jin Kim, M.D., Jeong-Min Lee, M.D., In-Hwan Kim, M.D.,
Hyo-Sung Kwak, M.D., Young-Min Han, M.D., Chong-Soo Kim, M.D.

¹Department of Diagnostic Radiology, Chonbuk National University Hospital

Purpose: To compare liver hemangioma with hepatocellular carcinoma (HCC), as seen on superparamagnetic iron oxide (SPIO)-enhanced MR images.

Materials and Methods: The study involved 30 patients with 51 focal hepatic mass lesions (31 hemangiomas, 20 HCCs). Breath-hold T1-weighted fast low angle shot (FLASH) and respiratory-triggered T2-weighted turbo-spin echo (TSE) images were obtained at 1.5 T before and after intravenous administration of SPIO particles. For quantitative analysis, percentage signal intensity change (PSIC) and contrast-to-noise ratio (CNR) of the lesions were calculated for T1-weighted FLASH and T2-weighted TSE before and after intravenous administration of SPIO particles. In addition, lesion conspicuity and imaging artifacts were analyzed qualitatively.

Results: After SPIO administration, percentage signal intensity increase on T1-weighted FLASH images was $73.0 \pm 22.1\%$ for hemangiomas and $21.8 \pm 12.6\%$ for HCCs, the difference being significant ($p < 0.05$). Taking a signal increase of 40% on postcontrast T1-weighted FLASH as the cut-off value, sensitivity and specificity for hemangiomas were 96.8% and 100%, respectively. In addition, the percentages of signal intensity loss on T2-weighted TSE images for hemangiomas and HCCs were $35.5 \pm 17.2\%$ and $0.2 \pm 10.5\%$, respectively ($p < 0.05$). A comparison of lesion to liver CNR before and after SPIO infusion showed readings for hemangiomas and HCCs, respectively - of 15.4 ± 6.0 and 4.7 ± 4.4 on T1-weighted FLASH images, and -2.6 ± 0.7 and 2.7 ± 4.4 on T2-weighted TSE images ($p < 0.05$). Qualitative analysis indicated that the conspicuity of HCCs was noticeably greater on postcontrast T2-weighted TSE images than on precontrast images ($p < 0.05$).

Conclusion: The positive enhancement seen on T1-weighted FLASH images and the negative enhancement on T2 weighted TSE observed in liver hemangiomas after the administration of SPIO particles are valuable diagnostic features that can help characterize hemangiomas and differentiate them from HCCs.

Index words : Magnetic resonance (MR), contrast agents
Liver neoplasms, MR
Magnetic resonance (MR), contrast enhancement

Address reprint requests to : Jeong-Min Lee, M.D., Department of Diagnostic Radiology, Chonbuk National University Hospital,
634-18, Keumam-Dong, Chon Buk 561-712, Korea.
Tel. 82-63-250-1152 Fax. 82-63-272-0481