Journal of the Korean Radiological Society 1996 ; 35(6) : 929~937

Breath-Hold MR Imaging of Focal Hepatic Lesions : Clinical Usefulness of Breath-Hold TSE T2WI Combined by Fast Low-Angle Shot (FLASH) MR Imaging [1]

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Purpose : To compare the image quality and diagnostic efficacy of turbo spin-echo (TSE) T2WI with breath-hold turbo SE T2WI and to evaluate the clinical usefulness combined breath-hold turbo SE T2WI with FLASH(fast low-angle shot) MR imaging for the evaluation of focal hepatic lesions.

Materials and Methods : A total of 47 patients with known or suspected hepatic mass were prospectively evaluated using a commercially available 1.5−T MR system. All patients were examined with conventional spin-echo T1WI, TSE T2WI, breath-hold TSE T2WI, and T1-weighted FLASH with and without Gd-DTPA. The images were compared quantitatively (liver-lesion C/N; CNR [contrast-to-noise ratio] and lesion detectability) and qualitatively (sharpness of anatomic structure, artifact, and overall image quality).

Results : A total of 69 hepatic lesions were detected in 47 patients. Sixty-seven lesions (97.1%) were detected with Gd-FLASH, 66 (95.7%) with TSE T2WI, 65 (94.2 %) with breath-hold TSE T2WI, 62 (89.9%) with non-enhanced FLASH, and 55 (79.7 %) with conventional SE T1WI. The CNR of cysts and hemangiomas was significantly greater on turbo SE T2WI and breath-hold TSE T2WI than on other sequences, but there was no significant difference between turbo SE T2WI and breath-hold TSE T2WI. For solid lesions, CNR was greatest on turbo SE T2WI and was similar on breath-hold TSE T2WI and Gd-FLASH without statistical significance, but was significantly higher than conventional SE T1WI. Breath-hold TSE T2WI and Gd-FLASH were qualitatively superior to other sequences except the vascular pulsation artifact of FLASH. Non-enhanced FLASH was also superior to conventional T1WI for CNR, lesion detectability, sharpness, respiratory motion artifact, and overall image quality.

Conclusion : Breath-hold TSE T2WI may replace turbo SE T2WI, and as well as conventional SE T1WI, FLASH with or without Gd-DTPA may be used for the evaluation of focal hepatic lesions. The combination of FLASH and breath-hold TSE T2WI may be an excellent technique that can be used to rapidly evaluate liver lesions, and at the same time offer superior overall image quality.

Index Words : Liver neoplasms, MR
Magnetic resonance(MR), technology

INTRODUCTION

T2-weighted spin-echo magnetic resonance (MR) imaging has proved to be a useful and effective means for the detection of hepatic lesions at high field strength (1−6). However, the limitations of conventional T2-weighted spin-echo (SE) sequences are; lengthy acquisition times, image degradation due to motion artifacts, and decreased signal-to-noise ratio. Turbo SE sequences can provide high-quality T2-weighted images in a much less time than is needed for conventional SE imaging, but motion-induced artifacts do remain a problem (4−7).

Rapid gradient-echo imaging techniques have recently been proposed as another way to scan the abdomen.

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These techniques include ; fast low-angle shot (FLASH) (1, 8, 9), fast imaging with steady-state precession (FISP) (10), reversed FISP (3D-PSIF) (2), and turbo FLASH (11). However, rapid gradient-echo imaging techniques provide mainly T1-weighted tissue contrast with dynamic gadolinium-enhanced MR images (6, 12−14).

The purpose of this study was to compare turbo SE T2-weighted sequences with breath-hold turbo SE T2-weighted sequences for image quality and diagnostic efficacy and to evaluate the clinical usefulness of the combination of breath-hold turbo SE T2-weighted MR imaging and T1-weighted FLASH MR imaging for the evaluation of focal hepatic lesions.

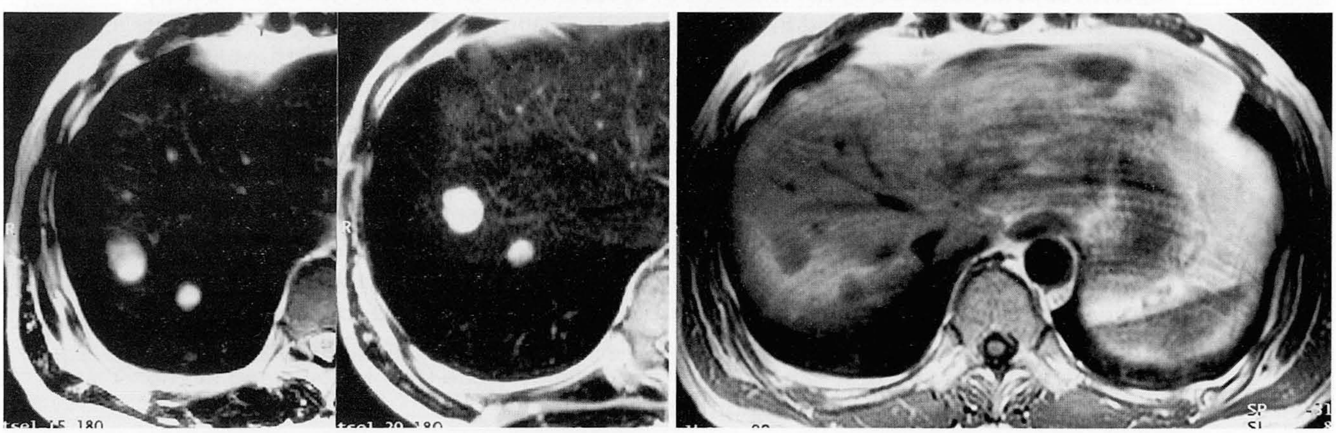
MATERIALS and METHODS

Subjects

A total of 47 patients with known or suspected hepatic mass were prospectively evaluated with a commercially available 1.5−T MR system (Magnetom VISION ; Siemens, Erlangen, Germany). The patients were between 27 and 85 years old (mean, 52.7years) and included 15 women and 32 men. They had a total of 67 lesions : 17 primary hepatocellular carcinomas, 13 hemangiomas, three metastatic lesions (two stomach carcinomas, one colon carcinoma), two intrahepatic cholangiocarcinomas, and 12 simple hepatic cysts. The hepatomas, metastases, and cholangiocarcinomas were confirmed pathologically by surgery or fine needle aspiration biopsy. The diagnoses of hemangiomas and simple hepatic cysts were based on characteristic imaging findings on CT scans, sonograms, scintigrams, or MR images.

Imaging Protocol

All patients were examined with conventional SE T1-weighted images, turbo SE T2-weighted images, breath-hold turbo SE T2-weighted images, and T1-weighted FLASH with and without Gd-DTPA. All images were acquired in the transaxial plane with a section thickness of 8mm and an intersection gap of 1.6 mm. The patients were instructed to suspend breathing at half expiration for all breath-hold sequences. Conventional SE T1- weighted imaging (500/12−16 [TR/TE]) was performed, and tow signals were averaged. A 192×256 acquisition matrix and 150Hz sampling bandwidth were used, with an imaging time of 5−6 minutes. Turbo SE T2- weighted images (4500−5000/130−138) were obtained with a 210×256 matrix, an echo train length of 15, two excitations, and a bandwidth of 130Hz. For the breath-hold turbo SE T2-



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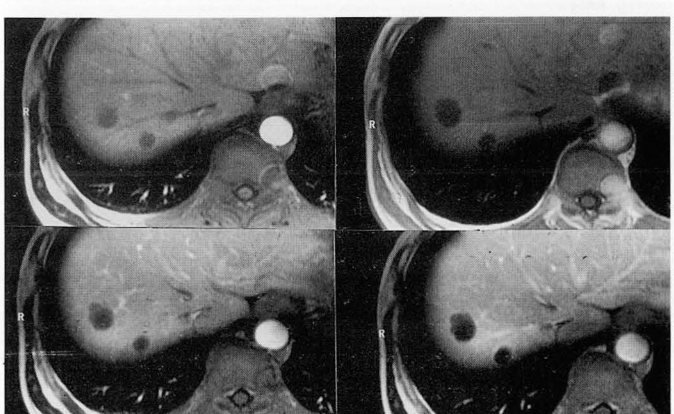

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Fig. 1. MR images of a 58-year-old patient with hepatic cysts.
a. Conventional turbo SE T2WI (4500/132, 15 echo train length) (left) vs breath-hold turbo SE T2WI (3540/138, 29 echo train length) (right).
b. SE T1WI (580/14) with respiratory artifacts that obscure the anatomic structures.
c. Four sections obtained with the FLASH sequences (117/4. 1, 80o flip angle) show the absence of motion-induced artifacts with good visualization of intrahepatic vessels and diaphragm as compared with SE T1WI. Cysts are not enhanced till delayed five-minute image.

weighted images, parameters were TR, 3500—4000 msec ; TE, 130—138 msec ; a 116×256 matrix ; one excitation ; a sampling bandwidth of 260Hz ; and an echo train length of 29, with saturation pulses superior and inferior to the section. Acquisition time was 4—6 minutes on the turbo SE T2-weighted images and was 17—20 sec on the breath-hold turbo SE T2- weighted images, respectively. FLASH imaging was performed with sections encompassing the entire liver in one breath hold. Imaging parameters were 117/4.1 ; one signal average ; flip angle 80° ; matrix size, 232×256. Acquisition time was 18—20sec. Following the initial FLASH sequence, 0.1m mol/kg of gedopentetate dimeglumine was given and as a bolus injection over approximately 20 seconds with the patient positioned in the bore of the magnet. 15mL of normal saline solution was rapidly flushed through the 100-cm intravenous extension tubing. Postcontrast FLASH images were obtained at 25, 50, and 75 seconds and 5 minutes after the saline flush. In all imaging sequences, the field of view was 310—400mm.

Image Analysis

The signal intensity of liver lesions and normal liver parenchyma was measured with an electronic cursor. The calculations of contrast-to-noise ratio (CNR) were performed as follows : CNR=(signal intensity of lesion-signal intensity of liver)/standard deviation of noise signal intensity (15, 26). Region of interest (ROI) analysis of images was performed by a single observer (T.H. K.), for the liver, an ROI was drawn as large as possible without the inclusion of surrounding tissues, especially blood vessels. The size and contour of the ROIs were therefore not exactly the same for images obtained with all sequences. Mean values of two measurements were used. For liver lesions, an ROI was drawn as large as possible to encompass as much of the lesion as possible. Standard deviation of noise signal inten-

Table 1. Lesion Detectability by Image Sequence (n=69)

Sequence	No. of lesion(%)
Gd-FLASH	67(97.1)
Turbo SE T2WI	66(96.4)
BH TSE T2WI	65(95.6)
FLASH	62(89.9)
CSE T1WI	55(79.7)

Gd-FLASH : Gd-enhanced FLASH images,
Turbo SE T2WI : turbo spin-echo T2-weighted images,
BH TSE T2WI : breath-hold turbo spin-echo T2-weighted images,
FLASH : fast low-angle shot images,
CSE T1WI : conventional spin-echo T1-weighted images.

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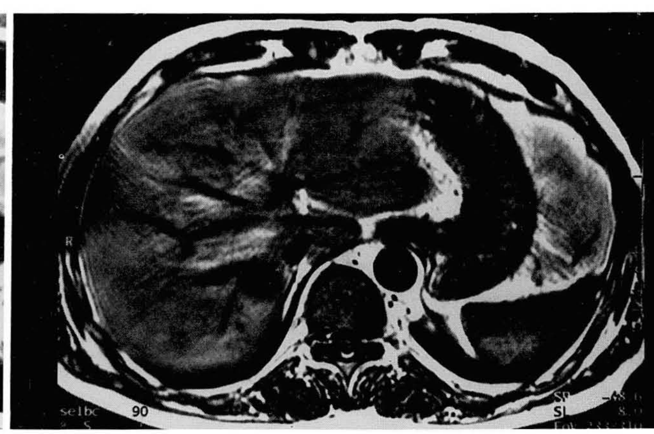

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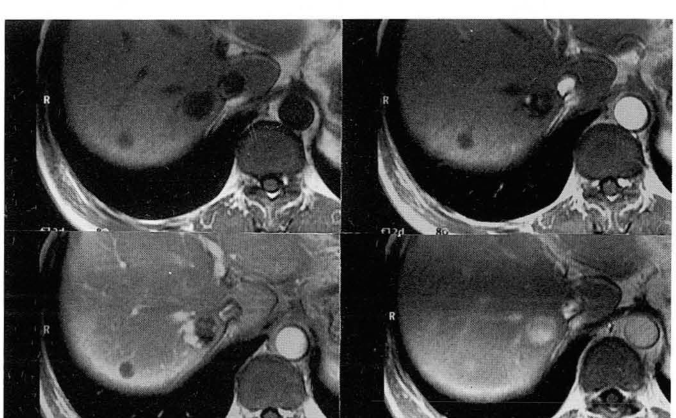

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Fig. 2. MR images in a 56-year-old patient with hemangiomas in the right hepatic lobe.
a. Conventional TSE T2WI (4500/132, 15 echo train length) (left) and breath-hold TSE T2WI (3540/138, 29 echo train length) (right) show the high signal intensity lesion.
b. SE T1WI (540/14) with motion-induced artifacts.
c. Sequential contrast-enhanced FLASH (117/4.1, 80° flip angle) MR images show discontinuous peripheral nodular enhancement (top right), with progressive centripetal enhancement (bottom left). Five-minute contrast-enhanced FLASH image demonstrates diffuse homogenous enhancement (bottom right).

sity was measured as far as possible from the image in the phase-encoding direction anterior to the abdomen. CNRs of hepatic lesions (hemangiomas, cysts, and solid masses) were compared with various pulse sequences.

All images were assessed by two radiologists (T.H. K., K.W.K.) in consensus. Lesion detectability was compared with all other imaging sequences. Qualitative evaluation was based on the following criteria: sharpness of anatomic structures, presence of respiratory motion and vascular pulsation artifacts, and overall image quality. The sharpness of anatomic structures was based on an analysis of the ability to detect internal structures (intrahepatic vessels) and the detection of the edges of normal structures (liver, pancreas, spleen, and kidney); the criteria for evaluation were as follows: extreme blur, moderate blur, mild blur, and sharp. Artifacts were ranked as none, mild, moderate, or severe. Overall image quality was also evaluated as poor, fair, good, or excellent. Statistical analysis was performed with the Wilcoxon signed rank and sign tests (19).

Table 2. Results of Quantitative Evaluation of Focal Hepatic Lesions by Imaging Sequence

	Total	Cyst	Hemangioma	Solid mass
Sequence	(n=69)	(n=24)	(n=17)	(n=28)
Turbo SE T2WI	29.5±17.8*	38.3±10.4♥	38.8±18.7♣	19.1±12.8♠
BH TSE T2WI	27.2±13.5*	36.8±15.3♥	32.2±10.6♠	17.0±9.5
Gd-FLASH	15.8±12.4	17.9±15.0	14.5±7.5	16.2±12.3
FLASH	13.8±7.2	16.4±7.8	13.4±10.4	11.7±6.4
CSE T1WI	11.1±8.8	15.5±11.7	10.9±8.2	8.5±6.1

Data (CNR) : mean +SD. *, ♥, ♣, ♠ : statistical significance achieved at $p < 0.05$ level. Total : total mass of the liver,
Turbo SE T2WI : turbo spin-echo T2-weighted images, BH TSE T2WI : breath-hold turbo spin-echo T2-weighted images,
Gd-FLASH : Gd-enhanced fast low-angle shot images, FLASH : fast low-angle shot images,
CSE T1WI : conventional spin-echo T1-weighted images.

Table 3. Results of Qualitative Evaluation in 47 Patients.

Parameter	Sequence(%)				
	SE T1WI	TSE T2W	BH TSE T2WI	FLASH	Gd-FLASH
Motion artifact					
Breathing					
None	5(11)	6(13)	21(45)	23(49)	21(45)
Mild	17(36)	25(53)	16(34)	20(43)	19(40)
Moderate	19(40)	13(28)	8(17)	2(4)	4(9)
Severe	6(13)	3(6)	2(4)	2(4)	3(6)
Vascular pulsation					
None	28(60)	21(45)	19(40)	0(0)	0(0)
Mild	13(28)	23(49)	26(55)	16(34)	20(43)
Moderate	6(13)	3(6)	2(4)	25(53)	19(40)
Severe	0(0)	0(0)	0(0)	6(13)	8(17)
Edge sharpness					
Sharp	5(11)	7(15)	26(55)	25(53)	19(40)
Mild blur	20(43)	23(49)	12(26)	16(34)	22(47)
Moderate blur	18(38)	15(32)	8(17)	5(11)	4(9)
Extreme blur	4(9)	2(4)	1(2)	1(2)	2(4)
Overall image quality					
Excellent	6(13)	7(15)	21(45)	24(51)	15(32)
Good	21(45)	23(49)	15(32)	16(34)	20(43)
Fair	15(32)	14(30)	9(19)	6(13)	10(21)
Poor	5(11)	3(6)	2(4)	1(2)	2(4)

SE T1WI : spin-echo T1-weighted images, TSE T2WI : turbo spin-echo T2-weighted images,
BH TSE T2WI : breath-hold turbo spin-echo T2-weighted images, FLASH : fast low-angle shot images,
Gd-FLASH : Gd-enhanced fast low-angle shot images

RESULTS

A total of 69 hepatic lesions were detected in 47 patients. Lesion detectability was 67 (97.1 %) with Gd-FLASH, 66 (96.4 %) with turbo SE T2-weighted images, 65 (95.6 %) with breath-hold turbo SE images, 62 (89.9 %) with non-enhanced FLASH, and 55 (79.7 %) with conventional SE T1-weighted images (Table 1).

For all hepatic lesions, CNR was significantly greater on turbo SE T2-weighted images (29.5) and breath-hold turbo SE T2-weighted images (27.2) than on FLASH with/without Gd-DTPA (15.8/13.8) and conventional SE T1-weighted images (11.1) ($p < 0.05$). There was, however no significant difference between turbo SE T2-weighted images and breath-hold turbo SE T2-weighted images (Table 2). CNR of cysts was significantly greater on turbo SE T2-weighted images (38.3) and breath-hold turbo SE T2-weighted images (36.8), than on any other sequences (Table 2, Fig. 1). CNR of hemangiomas was the same as for cysts (Table 2, Fig. 2). For solid lesions, CNR was greatest on turbo SE T2-weighted images and was similar on breath-hold turbo SE T2-weighted images and Gd-FLASH without statistical significance, but was significantly higher than on conventional SE T1-weighted images (Table 2, Fig. 3, 4). Breath-hold turbo SE T2-weighted images and Gd-FLASH were qualitativly superior to other sequences except the vascular pulsation artifact of FLASH (Table 3). Breath-hold turbo SE T2-weighted images were inferior to turbo SE T2-weighted images in lesion detectability (Table 1), but there was no statistical difference in CNR (Table 2). Non-enhanced FLASH was also superior to conventional T1-weighted images for CNR, lesion delectability, sharpness, respiratory motion artifact, and overall image quality (Table 1 – 3).

DISCUSSION

High soft-tissue contrast and the absence of motion-induced image artifacts with rapid acquisition time are the major prerequisites for the detection of liver lesions in MR imaging of the abdomen (9). SE T2-weighted images are superior to T1-weighted SE sequences in lesion detection at higher field strengths because of high soft-tissue contrast (1 – 6). However, the limitations of conventional T2-weighted SE sequences are long examination times and high susceptibility to motion induced artifacts.

Turbo SE sequences provide high-quality images in significantly less time than is required for conventional

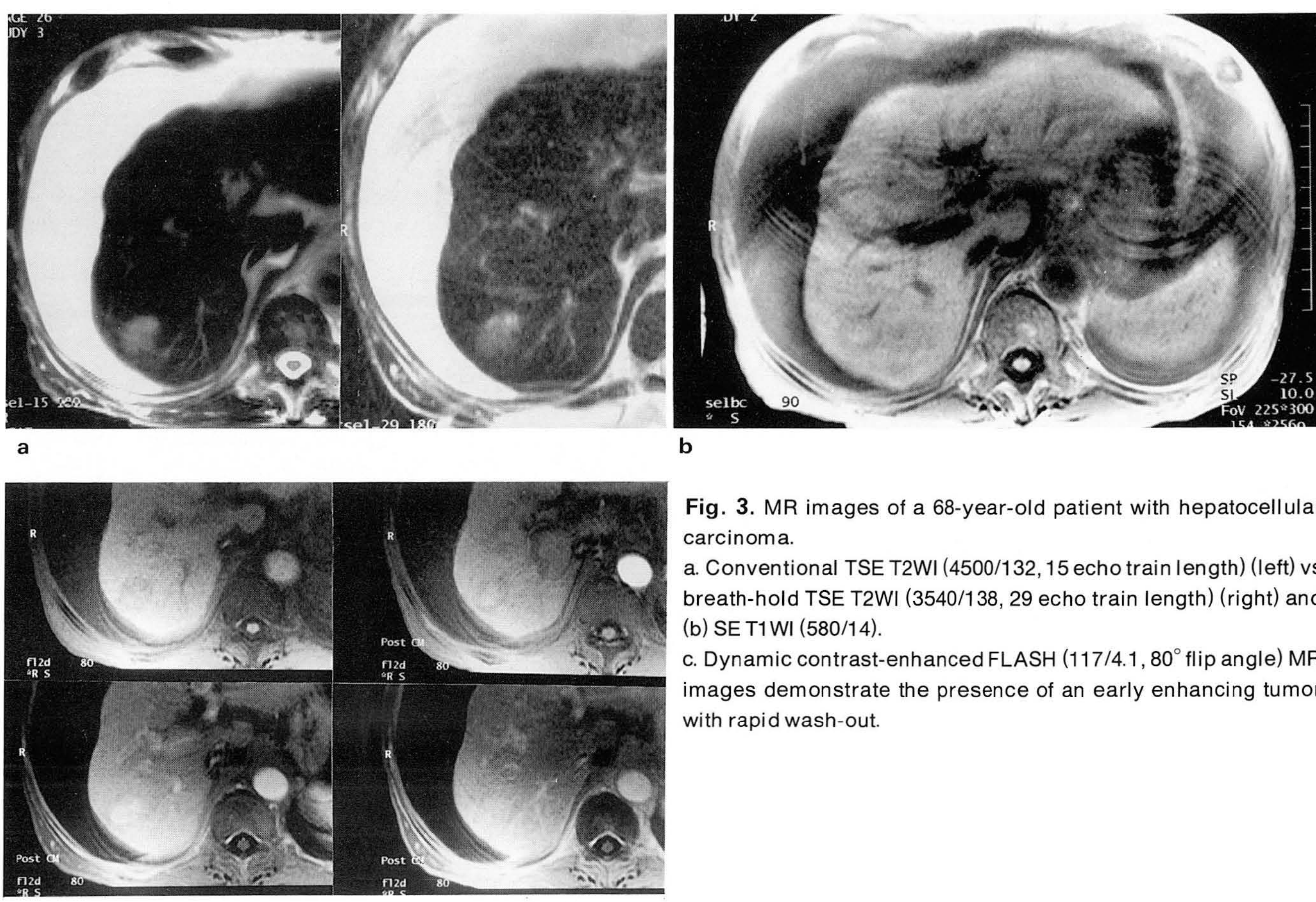

Fig. 3. MR images of a 68-year-old patient with hepatocellular carcinoma.
a. Conventional TSE T2WI (4500/132, 15 echo train length) (left) vs breath-hold TSE T2WI (3540/138, 29 echo train length) (right) and (b) SE T1WI (580/14).
c. Dynamic contrast-enhanced FLASH (117/4.1, 80° flip angle) MR images demonstrate the presence of an early enhancing tumor with rapid wash-out.

SE imaging, but the problem is respiratory motion-induced artifacts. Turbo SE was developed by Hennig et al. (16). Multiple 180° refocusing RF pulses are applied with a different phase-encoding value, thus decreasing the acquisition time proportional to the echo train length. The reduction in imaging time can be used to improve image quality (4, 7, 8, 11). The increased number of excitations can be used to increase the SNR and to decrease the prominence of respiratory ghost and vascular pulsation artifacts. Spatial resolution can be improved by using a larger matrix. In this study, turbo SE T2-weighted images had an echo train length of 15, a 210×256 matrix, two excitations, and acquisition time of 4–6 minutes. Our data still show poor image quality due to respiratory motion-induced artifacts, however (Table 3). Breath-hold turbo SE T2-weighted images and turbo SE T2-weighted images show similar CNR (Table 1, 2), the former also decreases motion induced artifacts from respiratory suspension during image acquisition. To reduce the imaging times, parameters are as follows ; one acquisition, a 116×256 matrix, an echo train length of 29. Eleven sections can be obtained in 16-20 seconds with one breath-holding period. Because twenty-nine 180° refocusing pulses per TR interval are applied with varied phase encoding, four TRs are needed for the filling of the K-space.

Tissue contrast on turbo SE images is nearly identical to that on conventional SE images, and the former might replace the latter for imaging the brain, spine, and pelvis (17, 18). Catasca et al. (4) showed, however, that nearly all solid abdominal organs or mass lesions showed a lower signal intensity on turbo SE images than on conventional SE images. The higher signal intensity of abdominal fat on the turbo SE images could account for the decreased range of tissue contrast represented on a relative scale. This effect increases as the number of refocusing pulses increases and as the time between refocusing pulses decreases (4, 5). Tissue contrast will also be influenced by different amounts of T2-decay, was caused by varying refocusing pulses on turbo SE images. In our data, con-

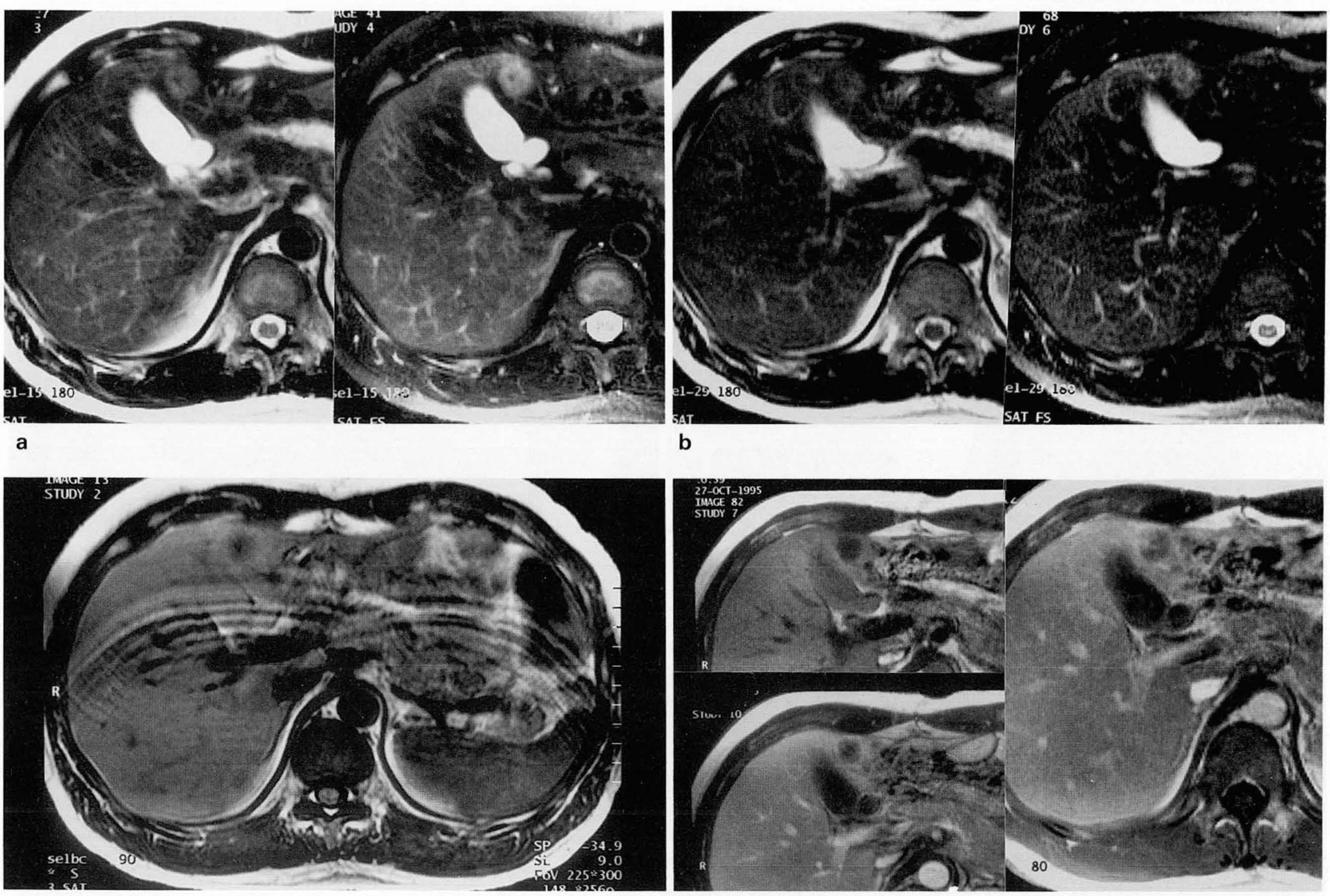

Fig. 4. MR images in a 46-year-old patient with a live metastasis from stomach cancer.

a. Conventional TSE T2WI (4500/132, 15 echo train length) (left) with fat suppression (right), and (b) breath-hold TSE T2WI (3540/138, 29 echo train length) (left) with fat suppression (right).

c. SE T1WI (540/14) with respiratory motion artifacts.

d. Dynamic contrast-enhanced FLASH (117/4.1, 80° flip angle) MR images show peripheral rim enhancement that progressed in a centripetal fashion.

ventional SE sequences were not used, but we thought that turbo SE sequences with echo train length of 15 would influence the tissue contrast. CNR and lesion detectability on turbo SE T2-weighted images were actually superior to those on breath-hold turbo SE T2-weighted images, but differences between them were ot significant (Table 1, 2). On turbo SE images, magnetization transfer contributes to some loss of signal intensity in solid tissues (4, 7, 20, 21, 26). Magnetization transfer refers to the cross relaxation between free unbound water protons and protons bound to the surface of macromolecules in protein solutions and tissues ; these effects are thus generated by the multiple 180° refocusing pulses used in the turbo SE sequences (20, 21, 26). Increased magnetization transfer effects may lead to relatively lower signal intensity ratios of solid lesions (20, 21). Thus, as echo train length increases, tissue contrast and loss of signal intensity of solid lesions will increase. In our study, CNR for solid lesions was greater on turbo SE T2-weighted images than on other sequences, but there was no statistical significance with FLASH sequences (Table 2, Figure 3, 4). Cystic lesions or hemangiomas undergo little or no magnetization transfer effect, however and have more heavily T2-weighted imaging parameters. Consequently, the difference in the tissue contrast between cystic lesions or hemangiomas and solid lesions would be relatively greater on the turbo SE images than on the conventional SE images (4, 7, 21, 26). Lesion detectability and CNR were actually significantly higher on turbo SE T2-weighted images than on FLASH and conventional SE T1-weighted images, but those for breath-hold turbo SE T2-weighted images which had longer echo trains were inferior to those for turbo SE T2-weighted images, without statistical significance. Effective TE as well as the effect of magnetization are also major elements that theoretically alter tissue contrast on turbo SE images (4, 7). Multiple 180o refocusing pulses per TR interval have a different T2 decay. The middle lines of K-space primarily determine tissue contrast and SNR. Tissue contrast will thus be influenced primarily by the T2 decay consistent with a given operator-selected TE (4).

Overall image quality for the turbo SE T2-weighted sequence was found to be significantly inferior to that obtained for the breath-hold turbo SE T2-weighted sequence, probably due to decreased respiratory-induced motion artifacts (Table 3). Although the resultant image blurring would be expected to increase with increasing echo train length, particularly with a different echo delay, varying amounts of T2 decay, and transverse magnetization in the imaged tissue, motion-induced artifacts might be one of the major factors influencing image quality (3–5, 22). As echo train length increases, the magnetization susceptability effect and the vascular pulsation artifact decrease (4, 5). Generally, breath-hold turbo SE T2-weighted images were slightly inferior to turbo SE T2-weighted images for lesion detectability and tissue conrast, but there was no statistically significat difference between the two sequences. As a breath-hold turbo SE T2-weighted sequence provides high-quality images with fewer arifacts in significantly less time than is possible with a turbo SE T2-weighted sequence, we think that the breath-hold turbo SE T2-weighted sequence is a useful method for the detection of liver lesions. The potential limitation of a breath-hold turbo SE T2-weighted sequence is the restricted number of slices. In our study, 11 sections can be acquired within 18 seconds. At a section thickness of 8mm and an intersection gap of 1.6 mm, as was used in our study, about 10.5cm in length can be covered. However, if a slice thickness of 10–12 mm and an interslice gap of 2–3mm were applied, about 16–17cm in length could be covered. On the other hand, the entire liver can be imaged twice, if necesary, within a short acquisition time ; the imaging time of breath-hold turbo SE T2-weigedd sequence is only about 18 seconds.

FLASH is an MR imaging sequence that can acquire a T1-weighted image in less than 1 second per section (5, 6, 9, 12, 23). It has a very short TE, needed to obtain heavy T1-weighted images and to allow for high multi-slice capability. The FLASH technique thus also provides good image quality with less motion-induced artifacts. CNR on the FLASH images was also slightly superior than on conventional SE T1-weighted images, and lesion detectability was also higher on FLASH than on conventional SE T1-weighted images (Table 1, 2). Although the CNR of FLASH was inferior to that of turbo SE T2-weighted images, FLASH techniques were useful in dynamic images with Gd-DTPA ; CNR was 14% hegher on Gd-DTPA enhanced FLASH images than on unenhanced images, and also showed a 38% increase in CNR for solid mass lesions. In comparison, Edelman et al. (24) reported that CNR was 50% higher on Gd-DTPA enhanced FLASH images than on unenhanced images. Dynamic FLASH sequence images offer some potential for the characterization of lesions, and lesion detectability on FLASH is also slightly better than on turbo SE T2-weighted images (Table 1). Simple cysts showed relatively well-marginated, oval lesions with low signal intensity, or signal void lesions on enhanced dynamic FLASH imges and very high signal intensity on SE TE-weighted images (Figure 1). Hemangiomas showed as well-marginated lesions with some lobulated border, and were of low signal intensity on FLASH or conventional SE T1-weighted images. The enhancement patterns of hemangiomas appeared as peripheral nodular enhancement with gradual fill-in of the lesion with time, and diffuse enhancement on delayed images (Figure 2) (14, 25). Despite higher lesion detectability, CNR was lower on dynamic enhanced FLASH images than on turbo SE T2-weighted images. This appeared to be because of non enhanced or irregular enhanced patterns on cystic mass lesions such as hemangiomas or simple cysts. Hepatocellular carcinomas showed as relatively high vasucular solid mass lesions and also were of high signal intensity on SE T2-weighted images and of low signal intensity with a less clearly demarcated margin on conventional T1-weighted images or unenhanced FLASH images. These lesions demonstrated early inhomogenous enhancement with early wash-out on dynamic enhanced FLASH images (Figure 3). On the other hand, metastatic lesions showed peripheral rim enhancement that progressed in a centripetal fashion (Figure 4) (6, 13).

Lesion detectability was slightly inferior on breath-hold TSE T2-weighted images (95.6 %) than on conventional TSE T2-weighted images (96.4 %), but with breath-hold TSE T2-weighted images in combination with pre- and post-enhanced dynamic FLASH images there were no problems in the evaluation of hepatic focal lesions (97.1 %). Since FLASH images were free of respiratory motion-induced artifacts and were also superior to the conventional SE T1-weighted images with respect to CNR and overall image quality, we thought that breath-hold TSE T2-weighted iamges combined with dynamic enhanced FLASH images might provide good image quality and reduced acquisition time.

FLASH sequence limitations include a prominent vascular pulsation artifact arising from the aorta, which could obscure lesions, especially in the left lobe of the liver (5, 6, 9). Presaturation pulses have been used with other fast imaging sequences to decrease this flow artifact (27). Saturation pulses are not compatible with FLASH sequences, however (23). We are currently investigating the use of SWAP (changes of phase-encoding direction), where there is doubt regarding a focal lesion in the left lobe of the liver. Susceptability artifacts play a major role in gradient-echo sequences and also influence image quality. The TE of 4.1 msec approximates the fat-water in-phase time of the 1.5 T MR system ; signal losses at organ interfaces due to signal-canceling artifacts were thereby avoided. Metal implants such as surgical clips produced strong artifacts, which decreased with SE sequences and were also no seen with longer echo train turbo SE sequences (9, 23).

In conclusion, the breath-hold TSE T2-weighted sequence is slightly inferior to the TSE T2-weighted sequence as regards lesion detectability or tissue contrast for the evaluation of focal hepatic lesions, but the two are not significantly different. Compared with the conventional SE T1-weighted sequence, the FLASH sequence is also good method. Breath-hold turbo SE T2-weighted images may thus replace turbo SE T2-weighted images, and the FLASH sequence with and without Gd-DTPA may also be used instead of the conventional SE T1-weighted sequence for the evaluation of focal hepatic lesions. The combination of breath-hold turbo SE T2-weighted and FLASH images may be an excellent techniques that can be used to rapidly evaluate liver lesions while offering superior overall image quality.

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대 한 방 사 선 의 학 회 지 1996 : 35(6) : 929～937

국소적 간병변에 대한 호흡보상이 가능한 자기공명영상: 호흡보상-급속 스핀에코 T2-강조영상과 FLASH 영상 조합의 임상적 유용성[1]

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목 적 : 간병변에 대한 자기공명 영상 검사에서 기존의 급속스핀에코(turbo spin-echo : TSE) 방식의 T2-강조영상(T2WI)과 호흡보상(breath-hold)이 가능한 TSE 방식의 T2WI를 영상의 질과 진단적 효율면에서 비교하고, 호흡보상이 가능한 TSE T2WI와 FLASH 방식의 T1-강조영상(T1WI) 기법만으로도 기존의 고식적, 혹은 TSE 방식을 대체할 수 있는지 알아보고자 하였다.

대상 및 방법 : 간병변이 의심되거나 치료중인 47 명의 환자(남 : 여 = 32 : 15, 평균연령 = 52.7)를 대상으로 1.5 T 자기공명 영상장치를 이용하여 검사를 시행하였다. 모든 환자에 대해 고식적 SE T1WI, 기존의 TSE T2WI, breath-hold TSE T2WI 및 FLASH 영상을 얻었다. 대상환자는 원발성 간암이 17예, 혈관종이 13예, 전이암이 3예, 담관암이 2예였으며 단순낭종만 있었던 경우도 12예가 있었다. 종괴의 대조도와 발견율, 해부학적 경계의 명확도, 영상의 질, 인공유령물 등을 각 영상방식에 따라 비교하였다.

결 과 : 47명의 환자에서 69개의 종괴가 발견되었다. 각 영상별로 종괴의 발견율은 Gd-FLASH 97.1% (67/ 69), TSE T2WI 96.4%(66/ 69), breath-hold TSE T2WI 95.6%(65/ 69), 조영전-FLASH 89.9%(62/ 69), SE T1WI 79.7%(55/ 69)였다. 단순낭종과 혈관종괴에 대한 대조도는 TSE T2WI와 breath-hold TSE T2WI가 다른 세 군에 비해 통계적으로 의의 있게 높았으나 서로간에는 통계적인 차이가 없었다. 고형종괴의 대조도는 TSE T2WI (19.1)에서 가장 높게 나타났으나 breath-hold TSE T2WI (17.1), Gd-FLASH(16.2) 방식에서도 비슷한 결과를 보였으며 이들 세군 사이에서는 통계적 의의가 없었다. 질적인 면에서는 breath-hold TSE T2WI 및 Gd-FLASH 방식이 해부학적 경계의 명확도, 영상의 질, 호흡에 의한 인공유령물은 우수한 결과를 나타냈으나 혈관 박동에 의한 유령물은 FLASH 기법에서 높게 관찰되었다. Breath-hold TSE T2WI는 병소발견율에서는 TSE T2WI보다 다소 낮았으나 대조도 면에서는 통계적인 차이가 없었다. 조영전-FLASH 방식은 SE T1WI에 비해서 통계적인 차이는 없었지만 대조도, 종괴발견율 및 영상의 질적인 면에서 우수하였다.

결 론 : 국소적 간병변을 발견하는데 있어서 breath-hold TSE T2WI는 기존의 TSE T2WI를 대체할 수 있으리라 기대되며, 조영전-FLASH 방식은 고식적 SE T1WI를 대체 가능 하리라 생각된다. 따라서 breath-hold TSE T2WI, 조영전-FLASH 및 Gd-FLASH 영상들만의 조합으로도 짧은 시간에 양질의 간 영상을 얻을 수 있으리라 생각된다.

편집인의 글

Internet을 통한 방사선과학 및 관련분야의 정보를 얻을 수 있는 Web site 주소와 찾는 방법에 대하여 월레스기념 침례병원 진단방사선과의 전동진 선생의 기고가 있었습니다 (대한방사선의학회지 1996 ; 34 : 299-300). 전동진 선생이 추가로 제공한 Web site 주소중 독자의 관심 영역이라고 판단되는 것을 선정하여 알려드립니다.

※ Web site

- ftp://ftp.xray.hmc.psu.edu/acr_codes
  ACR [Index for Radiological Diagnoses] (4th Edition)

- http://www.rad.rpslmc.edu/~ajnr/ajnrhome.html
  [AJNR:American Journal of Neuroradiology]

- http://www.acponline.org/journals/annals/annaltoc.htm
  [Annals of Internal Medicine]

- http://www.hwc.ca:8080/cma/journals/carj/index.html
  [CARJ Online (Canadian Association of Radiologists Journal)]

- http://www-mitpress.mit.edu/jrnls-catalog/contneuro.html
  [Journal of Contemporary Neurology]
  (Massachusetts Institute of Technology)

- http://www.scar.rad.washington.edu/SCAR/JDI.html
  [Journal of Digital Imaging]
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