ELSEVIER

European Journal of Radiology 26 (1998) 257–260

EJR
EUROPEAN JOURNAL OF RADIOLOGY

Multiple single sections Turbo FLASH MR arterial portography in the detection of hepatic neoplasms

Hidemasa Uematsu *, Hiroki Yamada, Norihiro Sadato, Nobushige Hayashi, Kazutaka Yamamoto, Yoshiharu Yonekura, Yasushi Ishii

Department of Radiology and Biomedical Imaging Research Center, Fukui Medical School, 23 Shimoaizuki, Matsuoka-cho, Yoshida-gun, Fukui, Japan

Received 9 September 1996; received in revised form 23 December 1996; accepted 23 December 1996

Abstract

Objective: To determine the sensitivity of multiple single sections Turbo FLASH MR arterial portography (MRAP) in the detection of hepatic neoplasms. *Methods and Patients:* Twelve patients with hepatic mass underwent MRAP prior to hepatic resection. Findings of MRAP were compared with surgical specimen and intra-operative ultrasonography (US). *Results:* A total of 19 separate malignant neoplastic nodules were identified in the resected specimens or intra-operative ultrasonography. The sensitivity was 89.5% (17/19) for MRAP. MRAP depicted all neoplasms more than 1.0 cm in diameter. Two lesions not depicted on MRAP had a diameter of 5 and 9 mm, respectively. One lesion identified by MRAP was confirmed to false positive lesion by intra-operative US. *Conclusion:* Multiple single sections Turbo FLASH MRAP may be a valuable adjunct for pre-operative detection of malignant hepatic neoplasms.

Keywords: Liver; Hepatic neoplasms; Magnetic Resonance; Turbo FLASH; MRAP

1. Introduction

Magnetic resonance (MR) imaging has shown considerable utility in the evaluation of hepatic neoplasms [1,2]. A variety of fast MR imagings are now available for the detection and characterization of liver lesions [3]. Computed tomography arterial portography (CTAP) was first introduced by Matsui and co-workers [4] for the precise detection of malignant hepatic neoplasms. Pavone et al. [5] and Soyer et al. [6] reported the use of multislice FLASH MR imaging during arterial portography (MRAP), which combines the superior mesenteric artery injection of paramagnetic agent and MR imaging, in the evaluation of hepatic metastases.

The purpose of this study is to determine the sensitivity of multiple single sections Turbo FLASH MRAP in the detection of malignant hepatic neoplasms, by comparing it with surgery and intra-operative ultrasonographic (US) examination.

2. Methods and patients

2.1. Subjects

Twelve patients (nine men, three women), aged 54–82 years (mean, 64.6 years) with malignant hepatic neoplasms were planned surgical resection from April 1993 to March 1995 at our institution. All patients were referred for preoperative CT imaging, Spin Echo MR imaging and MRAP. All patients underwent partial hepatectomy after intraoperative US examination. Sixteen lesions were confirmed in the resected specimens. Three lesions (one patient) were found outside the area resected. These three lesions were identified by intra-op-

* Corresponding author. Tel.: +81 776 613111 (ext. 2335); fax: +81 776 618137; e-mail: uematsu@fmsrsa.fukui-med.ac.jp

0720-048X/98/$19.00
PII S0720-048X(96)01157-6

erative ultrasound and confirmed by a US guided fine needle biopsy.

The mean of malignant neoplastic nodules per patient was 1.6 (range, 1–4) and the mean neoplastic nodule diameter was 2.45 cm (0.5–7.0 cm). Histologic diagnoses included hepatocellular carcinoma (eight patients), and colorectal carcinoma metastases (four patients). The mean time from MRAP to surgery was 11.7 days (3–32 days). Informed consent for MRAP was obtained from all patients.

2.2. MRAP

MR imaging was performed with a 1.0-T super conducting magnet (Magnetom 42 SP; Siemens, Erlangen, Germany). To better evaluate lesion-to-liver contrast, phase reordering was employed for the Turbo FLASH sequence [7–9]. Prior to MRI, all subjects underwent conventional hepatic angiography using a 5-F end-hole angiographic catheter with no metal parts (Terumo, Tokyo, Japan). With the tip of the catheter placed into the superior mesenteric artery (SMA), the patient was transferred to the MR imaging unit. Multiple single sections Turbo FLASH MRAP was carried out with the following parameters: TR, 6.5 ms; TE, 3 ms; TI, 300 ms; interval delay time, 100 ms; flip angle, 8°. Image matrix size was 128 × 256 in the coronal plane, using a body coil and the field of view, 500 mm. Fourteen or 17 sections of 10 mm thickness without intersection gap were acquired within a single breath-hold period of 17–20 s. Patients were instructed to hold their breath during each MRAP series to eliminate motion artifact. About 5 s after the start of acquisition, 0.1 mmol/kg of Gd-DTPA (Magnevist®, Nihon Schering, Osaka, Japan) was injected into the SMA, flushed with 20 ml saline solution. Injection lasted about 10 s in all cases. After the injection of Gd-DTPA, the 2nd–6th consecutive dynamic acquisitions were performed with 10 s interval time.

2.3. Image analysis

Three radiologists (H.U., H.Y., A.K.) evaluated in conference before surgery, with knowledge of the CT and MR imaging findings. Lesion size was subdivided into three categories (≤ 1.0, 1.0–2.0 and > 2.0 cm). Criteria of hepatic neoplasm based on MRAP imaging was focal parenchymal perfusion defects. Defects of any shape other than a peripheral wedge and flat-shaped defect were considered neoplasms [10]. Perfusion defects around the gall bladder and porta hepatis, or those of the anterior medial aspect of the medial segment of left lobe were not considered to be neoplasms [11–14]. A focal hepatic malignant neoplasm visible on MRAP was scored as a true positive lesion only if it corresponded in location to a lesion found on the resected specimens or intra-operative US. Nodular lesions that were depicted by MRAP but not confirmed by pathologic analysis or intra-operative US were defined as false-positives. A focal low intensity lesion on MRAP was scored as a benign hepatic lesions such as hepatic cysts only if it corresponded in location to a cysts found on CT or MRI.

3. Results

All MRAP studies were successfully performed. During the first portal circulation of the blood containing the Gd-DTPA, maximum liver parenchymal enhancement was obtained. We evaluated these phase images. The sensitivity was 89.5% (17/19 malignant neoplastic nodules) for MRAP (Fig. 1). The percentage of lesions detected in relation to three categories is listed in Table 1. MRAP depicted all neoplasms more than 1.0 cm in diameter. MRAP depicted a lesion of 7 mm in diameter, which did not show up with CT or MR imaging. One lesion identified in Segment 8 at MRAP was confirmed to be false positive lesion by intra-operative US. Two lesions missed at MRAP had a diameter of 5 and 9 mm diameters, respectively. Three defects of peripheral wedge shape in two patients were confirmed to be pseudolesions by intra-operative US.

4. Discussion and conclusion

The Turbo FLASH sequence enables the acquisition of an image in a fraction of a second [7]. Usually, MRAP using multislice FLASH techniques involve acquisition of several slices during each TR [5,6]. This is advantageous for abdominal imaging, to avoid respiratory and peristaltic artifacts. Recently, various data acquisition schemes of Turbo FLASH imaging have been proposed to improve contrast between tumor and normal structures, which is probably the most important factor for detection of focal liver lesions.

For sub-second imaging, reordered phase encoding produced improved image contrast over that of standard Turbo FLASH [8,9]. To maximize contrast between lesion and enhanced liver parenchyma in MRAP, we selected a TI (inversion time) of 300 ms in this study.

Some investigators have reported about Helical or Spiral CTAP [15–19]. The reported sensitivities of this method were 72 [16], 94 [17] and 88% [19]. In this study, comparison between multiple single sections Turbo FLASH MRAP and CTAP was not performed. Such a comparative study was not feasible in our institution because the conventional CT scanner does not allow for complete imaging of the whole liver in one breath-holding period. However, even though CTAP comparative

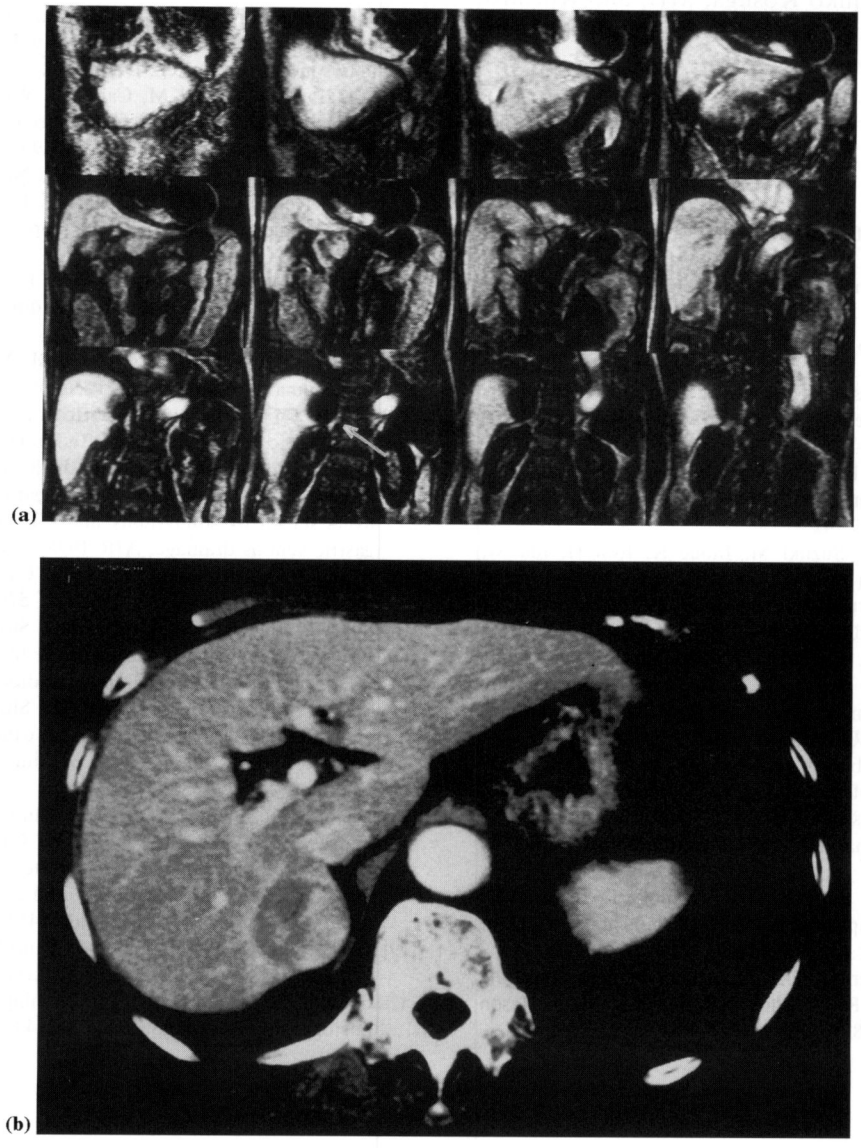

Fig. 1. MRAP images in an 82-year-old man with pathologically confirmed moderately differentiated hepatocellular carcinoma in segment 7 of the liver (diameter 3.5 cm). (a) MRAP images (6.5/3/300, with 8° flip angle) show significant increase in liver parenchymal signal intensity with no change in lesional signal intensity (arrow). (b) Delayed contrast enhanced CT image of the same patient.

data was not available, our results clearly indicate that MRAP is a modality to be seriously considered.

In conclusion, this study demonstrates that multiple single sections Turbo FLASH MRAP is a feasible and available imaging that can be used successfully. MRAP would be valuable to the readers with knowledge of the preoperative CT and MR imaging findings, to know additional true positive lesions. The choice between multiple single sections Turbo FLASH MRAP and CTAP can be determined according to availability of these imaging techniques.

Table 1
Correlation between size of hepatic neoplasms and detectability with MRAP

Diameter of neoplasms (cm)	No. depicted/total no.
≤1.0	3/5 (60)
1.0–2.0	5/5 (100)
>2.0	9/9 (100)
Total	17/19 (89.5)

Numbers in parentheses are percentages indicating sensitivity.

Acknowledgements

We thank Akane Kitagawa, MD, Hiroshi Inoue, RT, Koji Hayashi, RT, Tetsutaro Sakaguchi, MD, Masaki

Kobayashi, MD, Takahiko Kosuga, MD, and Kiichiro Watanabe, MD (Rakuwakai Otowa Hospital) for their many helpful discussions.

References

[1] Itoh K, Nishimura K, Togashi K, Fujisawa I, Noma S, Minami S, Sagoh T, Nakano Y, Itoh H, Mori K, Ozawa K, Torizuka K. Hepatocellular carcinoma: MR imaging. Radiology 1987; 164: 21–25.

[2] Matsui O, Kadoya M, Kameyama T, Yoshikawa J, Arai K, Gabata T, Takashima T, Nakamura Y, Terada T, Ida M. Adenomatous hyperplastic nodules in the cirrhotic liver: differentiation from hepatocellular carcinoma with MR imaging. Radiology 1989; 173: 123–126.

[3] Siewert S, Müller MF, Foley M, Wielopolski PA, Finn JP. Fast MR imaging of the liver: quantitative comparison of techniques. Radiology 1994; 193: 37–42.

[4] Matsui O, Kadoya M, Suzuki M, Inoue K, Itoh H, Ida M, Takashima T. Work in progress: dynamic sequential computed tomography during arterial portography in the detection of hepatic neoplasms. Radiology 1983; 146: 721–727.

[5] Pavone P, Giuliani S, Cardone G, Occhiato R, Renzi RD, Petroni GA, Buoni C, Passariello R. Intraarterial portography with gadopentetate dimeglumine: improved liver-to-lesion contrast in MR imaging. Radiology 1991; 179: 693–697.

[6] Soyer P, Laissy JP, Sibert A, Azencot M, Vissuzaine C, Marmuse JP, Achour E, Hercot O, Menu Y. Hepatic Metastases: Detection with multisection FLASH MR imaging during gadolinium chelete-enhanced arterial portography. Radiology 1993; 189: 401–405.

[7] Haase A, Matthaei D, Bartkowski R, Dühmke E, Leibfritz D. Inversion recovery snapshot FLASH MR imaging. J Comput Assisted Tomogr 1989; 13: 1036–1040.

[8] Holsinger AE, Riederer SJ. The importance of phase-encoding order in ultra-short TR snapshot MR imaging. Magn Reson Med 1990; 16: 481–488.

[9] Chien D, Atkinson DJ, Edelman RR. Strategies to improve contrast in turbo FLASH imaging: reordered phase encoding and K-space segmentation. JMRI 1991; 1: 63–70.

[10] Peterson MS, Baron RL, Dodd GD, Zajko AJ, Oliver JH, Miller WJ, Carr BI, Bron KM, Campbell WL, Sammon JK. Hepatic parenchymal perfusion defects detected with CTAP: imaging-pathologic correlation. Radiology 1992; 185: 149–155.

[11] Bluemke DA, Soyer P, Fishman EK. Nontumorous low-attenuation defects in the liver on helical CT during arterial portography: frequency, location, and appearance. AJR 1995; 164: 1141–1145.

[12] Soyer P, Lacheheb D, Levesque M. False-positive CT portography: correlation with pathologic findings. AJR 1993; 160: 285–289.

[13] Matsui O, Takahashi S, Kadoya M, Yoshikawa J, Gabata T, Takashima T, Kitagawa K. Pseudolesion in segment IV of the liver at CT during arterial portography: correlation with aberrant gastric venous drainage. Radiology 1994; 193: 31–35.

[14] Matsui O, Kadoya M, Takahashi S, Yoshikawa J, Gabata T, Takashima T, Kitagawa K. Focal sparing of segment IV in fatty livers shown by sonography and CT: correlation with aberrant gastric venous drainage. AJR 1995; 164: 1137–1140.

[15] Bluemke DA, Fishman EK. Spiral CT arterial portography of the liver. Radiology 1993; 186: 576–579.

[16] Soyer P, Bluemke DA, Hruban RH, Sitzmann JV, Fishman EK. Primary malignant neoplasms of the liver: detection with helical CT during arterial portography. Radiology 1994; 192: 389–392.

[17] Soyer P, Bluemke DA, Hruban RH, Sitzmann JV, Fishman EK. Hepatic metastases from colorectal cancer: detection and false-positive findings with helical CT during arterial portography. Radiology 1994; 193: 71–74.

[18] Irie T, Takeshita K, Wada Y, Kusano S, Terahata S, Tamai S, Hatsuse K, Aoki H, Sugiura Y. CT evaluation of hepatic tumors: comparison of CT with arterial portography, CT with infusion hepatic arteriography, and simultaneous use of both techniques. AJR 1995; 164: 1407–1412.

[19] Graf O, Dock WI, Lammer J, Thurnher S, Eibenberger KL, Wildling R, Niederle B, Lang EK, Lechner G. Determination of optimal time window for liver scanning with CT during arterial portography. Radiology 1994; 190: 43–47.