European Journal of Radiology 80 (2011) 310–315

Contents lists available at ScienceDirect

European Journal of Radiology

journal homepage: www.elsevier.com/locate/ejrad

Detection of hepatocellular carcinoma by Gd-EOB-DTPA-enhanced liver MRI: Comparison with triple phase 64 detector row helical CT

Hiroyuki Akai[a,*], Shigeru Kiryu[b], Izuru Matsuda[a], Jirou Satou[a], Hidemasa Takao[a], Taku Tajima[a], Yasushi Watanabe[c], Hiroshi Imamura[d], Norihiro Kokudo[e], Masaaki Akahane[a], Kuni Ohtomo[a]

[a] Department of Radiology, Graduate School of Medicine, University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8655, Japan
[b] Department of Radiology, Institute of Medical Science, University of Tokyo, 74-6-1 Shirokanedai, Minato-ku, Tokyo 108-8639, Japan
[c] Department of Radiological Technology, The University of Tokyo Hospital, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8655, Japan
[d] Department of Hepatobiliary-Pancreatic Surgery, Juntendo University School of Medicine, 3-1-3 Hongo, Bunkyo-ku, Tokyo 113-8431, Japan
[e] Hepato-Biliary-Pancreatic Surgery Division, Department of Surgery, Graduate School of Medicine, University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8655, Japan

ARTICLE INFO

Article history:
Received 14 May 2010
Accepted 27 July 2010

Keywords:
Gd-EOB-DTPA
Gadoxetic acid
Hepatocellular carcinoma
MRI
CT

ABSTRACT

Purpose: To compare the diagnostic performance of Gd-EOB-DTPA-enhanced MRI with that of triple phase 64-MDCT in the detection of hepatocellular carcinoma (HCC).
Patients and methods: Thirty-four patients with 52 surgically proven lesions underwent Gd-EOB-DTPA-enhanced MRI and triple phase 64-MDCT. Two observers independently evaluated MR and CT imaging on a lesion-by-lesion basis. Sensitivity, positive and negative predictive values and reproducibility were evaluated. The diagnostic accuracy of each modality was assessed with alternative-free response receiver operating characteristic (ROC) analysis.
Results: Both observers showed higher sensitivity in detecting lesions with MRI compared to CT, however, only the difference between the two imaging techniques for observer 2 was significant ($P = 0.034$). For lesions 1 cm or smaller, MRI and CT showed equal sensitivity (both 62.5%) with one observer, and MRI proved superior to CT with the other observer (MRI 75% vs. CT 56.3%), but the latter difference was not significant ($P = 0.083$). The difference in positive and negative predictive value between the two imaging techniques for each observer was not significant ($P > 0.05$). The areas under the ROC curve for each observer were 0.843 and 0.861 for MRI vs. 0.800 and 0.833 for CT and the differences were not significant. Reproducibility was higher using MRI for both observers, but the result was not significant (MRI 32/33 vs. CT 29/33, $P = 0.083$).
Conclusion: Gd-EOB-DTPA-enhanced MRI tended to show higher diagnostic accuracy, sensitivity and reproducibility compared to triple phase 64-MDCT in the detection of hepatocellular carcinoma, however statistical significance was not achieved.

1. Introduction

Hepatocellular carcinoma (HCC) is the most common primary hepatic malignant tumor. Potential curative treatments include surgical resection, radiofrequency ablation and laser coagulation. In the evaluation of HCC, it is important to diagnose the number and location of HCC accurately, so that the proper treatment can be chosen to improve the therapeutic outcome. Multiphasic helical CT has been the preferred diagnostic imaging technique, although magnetic resonance imaging (MRI) is gaining increasing popularity [1].

Gadolinium ethoxybenzyl diethylenetriamine pentaacetic acid (Gd-EOB-DTPA) has recently been developed as a liver-specific T1 contrast agent for MRI [2]. This agent allows for a new liver-specific MR imaging phase (i.e., a hepatocyte phase or a hepatobiliary phase) which has been proven to increase the detection of focal liver lesions [3–5]. Gd-EOB-DTPA also provides additional differential diagnostic information comparable to normal extracellular gadolinium chelates [6,7].

However, in all of these previous studies reports, dynamic and hepatobiliary phase imaging was performed using a two-dimensional (2-D) gradient-echo sequence [2–7]. Recent developments in MRI have allowed the use of parallel imaging. With the combination with T1-weighted 3-D gradient-echo sequences, acquisition of contiguous, thinner slices in a shorter time results in the detection of smaller lesions. On the other hand, development of

* Corresponding author. Tel.: +81 3 5800 8667; fax: +81 3 5800 8935.
E-mail address: hakai-tky@umin.ac.jp (H. Akai).

0720-048X/$ – see front matter © 2010 Elsevier Ireland Ltd. All rights reserved.
doi:10.1016/j.ejrad.2010.07.026

multi-detector row CT has also made it possible to acquire images in a shorter time, resulting in fewer motion artifacts and better spatial resolution and detection of smaller lesions.

We compared the diagnostic performance of Gd-EOB-DTPA-enhanced MRI with that of 64 detector row helical CT in the preoperative detection of HCC. In particular, we also assessed if a hypointense signal on the hepatobiliary phase of Gd-EOB-DTPA-enhanced MRI could more clearly delineate a HCC lesion compared to washout on the equilibrium phase of dynamic CT and if this finding was reproducible.

2. Materials and methods

2.1. Subjects

This study was approved by the institutional review board, and all subjects provided their written informed consent. Forty consecutive patients who had agreed to participate in this study and had undergone surgical resection of HCC at our institution from July 2008 to February 2009 were prospectively enrolled in this study. Of these, surgery could not be performed in one patient due to a massive hemorrhage, and this patient was excluded because no pathological proof was obtained. One patient found out to be asthma and could not perform CT and MRI, one patient had renal function failure and could not perform CT, two patients had innumerous HCCs, and only portal vein tumor thrombosis was found in one patient because of chemotherapy. We excluded these five patients because it was not suitable for analysis. The remaining 34 patients (27 men, 7 women; age range: 48–78 years; mean age: 65 years) with 52 pathologically proven HCCs (size range: 4–152 mm; mean size: 26 mm) were enrolled in the study. Eight of the 34 patients had two HCCs, 2 patients had 3 HCCs, and 2 patients had 4 HCCs. Of the 52 lesions examined, 16 were 1 cm in diameter or smaller.

2.2. Imaging techniques

All MRIs were performed using a 1.5 T system (Signa HDX 1.5 T; GE Medical Systems, Milwaukee, WI, USA). For all patients, unenhanced MRI, including T1-weighted (fast spoiled gradient recall sequence, repetition time (TR)/echo time (TE) 120 ms/2.2, 4.4 ms, flip angle 90°, number of excitations 1, field of view 35–40 cm, matrix 256 × 192, slice thickness 6 mm, bandwidth 488.3 Hz/pixel, scan time 15 × 2 s) and T2-weighted imaging with fat suppression (fast spin echo sequence, TE 80 ms, echo train length 12, number of excitations 2, flip angle 90°, field of view 35–40 cm, matrix 320 × 256, slice thickness 6 mm, bandwidth 122.1 Hz/pixel, asset factor 2, scan time 15 × 2 s), was obtained before the dynamic study.

The dynamic study was performed using the Liver Acquisition with Volume Acceleration (LAVA) sequence (TR/TE: 3.8–3.6/1.9–1.8 ms, number of excitations: 1, flip angle: 15°, FOV: 35–40 cm, matrix size: 320 × 160, slice thickness: 5 mm, bandwidth: 390.6 Hz/pixel, asset factor: 2, scan time: 9 s), a 3-D T1-weighted fast spoiled gradient-echo pulse sequence with fat suppression.

During the dynamic study, each patient was given 25 μmol/kg (0.1 ml/kg) of Gd-EOB-DTPA as an intravenous bolus using a power injector (Spectris Solaris EP; Nihon Medrad, Osaka, Japan), at a rate of 2 ml/s. The volume of contrast medium administered was 3.8–9.7 ml (mean 6.3 ml) depending on the patient's weight. The bolus injection was followed by a 20 ml saline flush at a rate of 2 ml/s. A double arterial phase was obtained during a single breath hold with a scan delay of 20 s for the early arterial phase and 30 s for the late arterial phase followed by portal venous phase acquired at 60 s. After the dynamic study, hepatobiliary phase imaging was obtained 20 min after the injection using the LAVA sequence without a parallel imaging technique (TR/TE: 3.8–3.6 ms/1.9–1.8 ms, number of excitations: 1, flip angle: 15°, FOV: 35–40 cm, matrix size: 320 × 160, slice thickness: 5 mm, bandwidth: 325.5 Hz/pixel, scan time: 21 s).

All CT examinations were performed using a 64 detector row helical CT (Aquilion 64; Toshiba Medical, Tokyo, Japan; LightSpeed VCT; GE Medical Systems). The scan parameters for the Aquilion 64 included a collimation of 32 mm × 1 mm, a pitch factor of 0.656, a rotation time 0.5 s, and a tube voltage of 120 kV. The scan parameters for the LightSpeed VCT were a 64 mm × 0.65 mm collimation, a pitch factor of 0.984, a rotation time of 0.5 s, and a tube voltage of 120 kV. The tube current was controlled automatically using Volume EC and Auto mA. All scans were acquired in a cephalocaudal direction in 5-mm sections. A scout view was obtained before the unenhanced CT scan, followed by the contrast-enhanced multiphasic CT.

All patients were given an injection of nonionic contrast material at a dose of 2 ml/kg of body weight to a maximum dose of 100 ml using a power injector (Dual Shot GX; Nemotokyorindou, Tokyo, Japan) at a rate of 3 ml/s. A double arterial phase was obtained using a single breath hold with a scan delay of 27–8 s for the early arterial phase and 40 s for the late arterial phase, and the equilibrium phase was obtained 90 s after the injection.

2.3. Image analysis

The MRI and CT images were interpreted independently by two experienced board-certified abdominal radiologists who knew that the patients were at risk for HCC but had no other clinical information. During session 1, the MRI and CT images of all patients were analyzed. During session 2, to assess the reproducibility of each modality, the MRI and CT images of patients who had never received hepatectomy were analyzed again. These patients were chosen so that the observers could not identify the patients by the shape of the liver. During this session, 23 patients with 33 HCCs were analyzed. The two sessions were separated by at least a four-week interval.

Each session was composed of two separate readings that were more than two weeks apart and only one imaging modality was reviewed at each reading. To eliminate the influence of the order of review, one observer evaluated MRI first, and the other observer evaluated CT first. To reduce recall bias, the data sets were analyzed in random order.

During each reading, the observers were asked to determine the presence and location of HCCs and grade their diagnostic confidence using the following five-point scale: 1 = definitely not HCC; 2 = probably not HCC; 3 = indeterminate (Fig. 1); 4 = probable HCC; 5 = definite HCC (Fig. 2). For the CTs, lesions that showed hypervascularity on the arterial phase and a washout pattern on the equilibrium phase were considered positive for HCC. If the enhancement on the arterial phase or the washout pattern on equilibrium phase was vague, the lesion was scored a '3' or '4', based on the observer's preference. The same criteria used for the triple phase dynamic CT were used for the Gd-EOB-DTPA-enhanced dynamic MRI. In addition, hypervascular lesions that showed hypointensity on the hepatobiliary phase were considered positive for HCC. If a lesion showed a typical enhancement pattern on the dynamic study, the lesion was considered positive for HCC even though the lesion was isointense or hyperintense relative to surrounding liver parenchyma on the hepatobiliary phase [8]. Hypointense lesions on the hepatobiliary phase were scored a '3' if not visible on any other sequences. The lesions that scored a '4' or more were considered positive for HCC.