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Added diagnostic value of T2-weighted MR imaging to gadolinium-enhanced three-dimensional dynamic MR imaging for the detection of small hepatocellular carcinomas

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Abstract

Purpose: To assess the added value of T2-weighted MRI to gadolinium-enhanced dynamic MRI for detection of HCCs.
Materials and methods: Two readers retrospectively analyzed MRIs of 115 patients with 131 HCCs (size; 0.6–2.0 cm) that had been diagnosed by histology ($n = 41$) or imaging findings ($n = 90$). Two separate blind image analyses of the gadolinium set and the combined T2-weighted imaging and gadolinium sets were performed. Diagnostic accuracy was evaluated using the alternative-free response receiver operating characteristic method with four-point scale. Sensitivity and positive predictive value were also calculated.
Results: For both observers, the Az values and sensitivities with the combined T2-weighed imaging and gadolinium set (mean Az 0.806, sensitivity 84.7) were significantly higher than those with the gadolinium set (mean Az 0.660, sensitivity 59.9) ($p < 0.05$). The addition of T2-weighted imaging led to a change in diagnosis for 27 lesions by both observers, which at gadolinium set were assigned a confidence level of 1 or 2 but at additional reading of T2-weighted imaging were assigned a confidence level of 3 or 4. For the positive predictive values, each image set showed a similar value for each observer.
Conclusion: The addition of T2-weighted imaging to gadolinium-enhanced 3D dynamic imaging could be helpful in the detection of HCC by increasing reader confidence for HCCs with equivocal findings on gadolinium-enhanced MRIs.

Keywords: Liver; cirrhosis; Liver neoplasm; Magnetic resonance imaging; Contrast media

1. Introduction

As gadolinium-enhanced liver MRIs became reliable, extensive controversy regarding the diagnostic role of precontrast T2-weighted imaging in the evaluation of focal liver lesions, including HCCs, has arisen [1–5]. In particular, the role of precontrast MRI may be more limited when used for assessment of HCC in cirrhotic livers than when used to assess other liver tumors [2–4]. This limitation is partially due to HCCs showing variable signal intensities on unenhanced MRIs with substantial overlap in the signal intensities of small HCCs, dysplastic nodules, and regenerative nodules [6,7]. From this point of view, some reports suggest possible omission of T2-weighted MRI as a routine MR protocol for HCC by demonstrating that T2-weighted imaging added to gadolinium-enhanced MRI dose not provide diagnostic value in the detection and characterization of focal lesions in cirrhotic liver when compared with gadolinium-enhanced MRI alone [3,4].

However, using gadolinium-enhanced dynamic imaging alone might also be problematic in evaluating small HCCs (2 cm or less in size) [8] because many of them are depicted only during arterial phase imaging as hyperintensity, which are often difficult to differentiate from non-neoplastic hypervascular pseuolesions caused by small arterioportal shunts or atypical

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cirrhosis-related benign nodules [9,10]. Adding MRI with using a liver-specific agent, such as superparamagnetic iron oxide (SPIO), may resolve most of these problems [11]. However, the routine use of double contrast MRI is still not warranted in clinical practice due to high cost and patient discomfort.

Therefore, in this study we evaluated the additional role of T2-weighted imaging to gadolinium-enhanced 3D dynamic MRI for the detection of small HCC (2 cm or less in size) to clarify whether continued use of precontrast T2-weighted MR sequences are warranted as part of the routine protocol of liver MRI for HCC work-up. To this end, we conducted this study to compare the diagnostic accuracy and sensitivity of the gadolinium-enhanced 3D dynamic MRI and combined T2-weighted imaging and gadolinium-enhanced 3D dynamic MRI for the detection of small HCCs (≤20-mm) using an alternative-free response receiver operating characteristic (ROC) analysis according to two observers.

2. Materials and methods

2.1. Patients

We retrospectively reviewed our institutional database for liver MRIs conducted on patients with known cirrhosis or hepatitis performed at our institution, which is a tertiary referral hospital, between May 2004 and July 2006 and identified 342 patients with HCCs who underwent gadolinium-enhanced 3D-dynamic MR imaging. The institutional review board of our hospital approved this retrospective study.

For the 342 patients, final inclusion criteria were: (a) small HCCs of 2 cm or less in diameter with histologic proof or typical imaging findings including hepatic angiography and lipiodol CT, and (b) follow-up contrast-enhanced CT or MRI performed for at least 12 months (range: 12–28 months). Patients who had multinodular HCCs (more than ten) were excluded from this study, since inclusion of patients with too many HCCs could heavily influence statistical analysis of this study. Consequently, this study population included 115 patients (88 men and 27 women; age range: 40–74 years) with 131 HCCs (size range: 0.6 cm–2.0 cm; mean: 1.3 cm). No study patients had liver masses other than the HCCs, regenerating nodules, and hepatic cysts. All patients had liver cirrhosis associated with viral hepatitis B. Five of them also had viral hepatitis C. Based on the Child-Pugh classification, 101 patients were classified as Child class A, and the 14 remaining patient was classified as class B.

The final diagnosis for 41 HCCs of 33 patients was confirmed by pathologic analysis of surgical specimens. For the remaining 82 patients with 90 HCCs who underwent transarterial chemoembolization ($n = 72$) or radiofrequency ablation ($n = 10$), final diagnosis was based on a combination of image-guided biopsy ($n = 11$), lipiodol CT [12], and the characteristic imaging findings of superparamagnetic iron oxide (SPIO)-enhanced MRI (i.e., a focal discrete, nodular high signal intensity area relative to liver parenchyma on T2-weighted SPIO-enhanced MRI), follow-up CT or MRI and/or elevated serum alpha-fetoprotein levels (over 200 ng/ml) [13].

2.2. MR examination

All MRIs were performed using a 1.5 T super-conducting imager (Magnetom Symphony; Siemens, Enlargen, Germany) with a combination of a phased array body coil and a spine array coil for signal reception. mSENSE with a reduction factor of two was applied at an in-plane phase encoding direction. The respiratory-triggered T2-weighted TSE imaging was obtained using the following parameters: a TR/TE of 4200/76, an echo train length of 13, a 150° flip angle, a matrix of 202 × 384, and a slice thickness of 6.0 mm. The dynamic MRIs (volumetric interpolated breath-hold examination, VIBE: Siemens, Erlangen, Germany) with mSENSE were performed using the following parameters: a TR/TE of 4.3/2.0, a flip angle of 12°, a bandwidth of 450 Hz/Px, a matrix of 256 (read) × 135 (phase) × 40–46 (partition), an effective slice thickness of 3.5–4 mm and a field of view of 32–35 cm. The determination of scan delay for image acquisition timing was achieved using the test bolus technique, in which 1 mL of contrast media was injected along with a 20 mL saline flushing, and the vessel of interest (the abdominal aorta) was scanned approximately once per second. The mean delay time to peak aortic enhancement was 21 s (range, 17.0–23.0 s). Thus, for a sequential MR acquisition (center lines of *k*-space are acquired during the middle of the acquisition time), the mean delay times (time interval between bolus administration and the start of image acquisition) for the early arterial, late arterial, portal, and equilibrium phase were 20, 30, 60, and 180 s, respectively. The acquisition time for each phase was 10–11 s and the two arterial phases were performed consecutively during a single breath-hold for approximately 22 s. Gadobenate dimeglumine (Gd-BOPTA; MultiHance®, Bracco SpA, Milan, Italy) was injected at a dosage of 0.1 mmol/kg body-weight at a rate of 2 mL/s. The contrast was injected into the antecubital vein using an automated injector (Spectris MR; Medrad Europe, Maastricht, the Netherlands) and 20-mL of saline flushing followed the contrast injections.

2.3. Imaging analysis

Two faculty-level gastrointestinal radiologists reviewed the images independently. All images were reviewed using a 2000 × 2000 Picture Archiving and Communication System (PACS; Marotech, Seoul, Korea) monitor. The radiologists were aware of the overall goal of the study and that the patients were at risk for HCC before the reading session, but they were unaware of the presence or location of any liver lesions or of the results of the other imaging findings. Each observer first independently reviewed the gadolinium set (precontrast, early arterial, late arterial, portal, and equilibrium phases) then T2-weighted imaging was added for a combined review.

The criteria for hypervascular HCC on dynamic MRI were defined as a nodule showing enhancement foci during the early and/or late arterial phases and washout during the portal venous and equilibrium phases. In addition, for lesions that showed nodular enhancement on only the dynamic arterial phase image, as well as hypovascular lesions that did not fulfill the diagnostic criteria for a cyst (i.e. smooth margins, homogeneous