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"Reuse" study of low-tube-voltage CT arterial phase in the spoiled gadoxetic-acid liver MRI☆

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ABSTRACT

Objectives: To compare diagnostic accuracy of gadoxetic acid-enhanced magnetic resonance imaging (MRI) (original set) and original MRI combined with the arterial phase of low-tube-voltage computed tomography (CT) (hybrid set).
Methods: In hybrid set, we substituted the CT arterial phase for MRI arterial phase. Three observers independently interpreted. The accuracy of each image set was evaluated using the alternative-free response receiver operating characteristic method.
Results: The mean Az values for original set (0.96±0.01) was higher than that for hybrid set (0.94±0.01), but the difference was not significant (P=.10).
Conclusions: In cases with degradation of magnetic resonance arterial phase, reuse of CT arterial phase might be helpful instead of repeating MRI.

1. Introduction

Accurate detection and characterization is the ultimate goal of imaging for evaluation of focal liver lesions. Among focal liver lesions, hepatocellular carcinoma (HCC) is the most devastating disease. HCC is the fifth most frequently diagnosed cancer worldwide and the second leading cause of cancer-related death [1]. For the detection and diagnosis of HCC, multidetector computed tomography (MDCT) and magnetic resonance imaging (MRI) are the modalities of choice and have been used most commonly. In addition, a dynamic study with intravenous injection of contrast medium is essential for the detection and diagnosis of HCC [2]. Recent advances in various MRI contrast media have improved the diagnostic performance of liver MRI. Among numerous MRI contrast agents, gadoxetic acid disodium (Primovist; Bayer Healthcare, Berlin, Germany) is a tissue-specific targeted MRI contrast agent for liver imaging and is specialized for the detection of HCC [3]. Previous studies have shown that gadoxetic acid disodium-enhanced dynamic imaging and hepatobiliary phase imaging can achieve a higher detection rate and better characterization of HCC than unenhanced MRI and MDCT images [3–6].

The arterial phase is very important for detection and characterization in the diagnosis of HCC, and it is now possible to examine the whole liver during a single breath hold with an arterial phase because of fast imaging techniques for computed tomography (CT) and MRI. However, a recent study reported that the arterial phase of gadoxetic acid-enhanced MRI might be severely degraded by respiratory motion artifacts in a large proportion (17%) of the study population [7]. In addition, inappropriate optimization of the MRI system and other complex interactions of contemporary imager subsystems, such as the reconstruction algorithm, may result in image quality degradation in liver MRI [8]. In cases of severely degraded arterial phase MRI datasets, radiologists must decide whether to repeat the MRI examination or perform diagnosis using other MRI characteristics (e.g., delayed washout, pseudocapsule, diffusion restriction, T2 high-signal intensity) without the spoiled arterial phase.

Multiphase CT is another powerful modality for focal liver lesions and is the most commonly used screening tool for HCC [9]. Recently, several studies have shown that low-dose CT using 80 kVp and high milliamperes results in higher lesion conspicuity than 120 kVp CT scans in the arterial phase because of the high attenuation value of contrast material that results from an increased photoelectric effect, although more noise can be present in the images [10–12]. Moreover, a recent study reported that there is no significant difference between low-tube-voltage liver CT and MRI for detection of HCC, although MRI is superior to low-tube-voltage CT [13].

Gadoxetic acid disodium-enhanced liver MRI is the best modality for detection and evaluation of HCC because it provides various sequences absent in CT. However, acquisition of perfect arterial phase is sometimes difficult due to various artifacts. In some countries, liver dynamic CT should be performed prior to MRI because of insurance issues. On the basis of this background, we presumed that the arterial phase of a

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previously performed screening low-tube-voltage CT scan could be used to substitute for a spoiled arterial phase MRI. Therefore, the purpose of this study was to compare the diagnostic accuracy of original gadoxetic acid disodium-enhanced liver MRI and liver MRI substituted with the arterial phase of low-tube-voltage liver CT and to assess the feasibility of using the arterial phase of low-tube-voltage CT when the arterial phase of gadoxetic acid disodium-enhanced liver MRI is spoiled.

2. Materials and methods

2.1. Patient

The protocol for this retrospective study was approved by the institutional review board of our institution and the need for informed consent was waived. Patient confidentiality was guaranteed by using only anonymous data and radiologic images.

From our radiology information database, we retrieved data for 485 patients who underwent both low-tube-voltage (80 kVp) dynamic contrast-enhanced MDCT and gadoxetic acid-enhanced MRI with a 3-T system between May 2008 and January 2012.

Of the 485 patients who were initially deemed eligible for the study (Fig. 1), 427 were excluded for the following reasons: (a) the interval between CT and MRI was more than 30 days ($n=311$), (b) the patient was lost to follow-up ($n=72$), (c) the patient underwent radiofrequency ablation of the tumor during the interval between the two examinations ($n=29$), or (d) there was insufficient proof of tumor burden ($n=15$). Finally, 58 patients (47 men and 11 women; age range, 35–78 years; mean age, 58.3 years) with 78 HCC lesions were included. These patients met the following criteria: (a) HCC patients diagnosed via histopathologic confirmation ($n=47$) following surgical resection ($n=33$), percutaneous biopsy ($n=13$), or transplantation ($n=1$); (b) HCC patients proven based on characteristic image findings on MDCT, MRI, or lipiodol CT, or hepatic angiography, as well as a 1-year imaging follow-up study ($n=11$); (c) follow-up contrast-enhanced CT or MRI performed at least 1 year later; (d) less than 1 month interval between low-tube-voltage liver CT and gadoxetic acid-enhanced MRI; and (e) nonobese (≤27 kg/m^2) body mass index (BMI).

Mean body weight was 63.5 kg (range, 45–81 kg) and mean BMI was 24 (range, 19.1–26.6). Fifty-six patients had chronic liver disease (including chronic hepatitis and cirrhosis) related to chronic viral hepatitis B ($n=47$), alcoholic liver disease ($n=5$), or chronic viral hepatitis C ($n=4$).

Characteristic imaging features for the standard of reference were a combination of a typical enhancement pattern of HCC (hypervascularity on arterial phase and washout on portal or delayed phase), characteristic angiographic findings of HCC followed by sustained lipiodol accumulation in the lesion on follow-up CT after TACE (*trans*arterial *c*hemo*e*mbolization), and increased lesion size on the 1-year follow-up CT or MRI. Hypervascularity was defined as a hyperattenuated or hyperintense focal lesion compared with the surrounding liver parenchyma on either dynamic low-tube-voltage CT or MRI [14,15].

2.2. CT imaging protocol

Our modified low-dose CT examinations were performed with a 16-MDCT scanner (Sensation 16; Siemens, Erlangen, Germany) with detector configuration of 16×0.625, tube voltage of 80 kVp, tube current of 280 mA, gantry rotation time of 0.5 s, single breath-hold helical acquisition of 12–18 s depending on liver size, scan coverage of 190 mm, field of view of 300–320 mm, and slice thickness of 5 mm with no interslice gap. A reconstruction Kernel B30f was used in all cases. All patients were examined in the supine position on the CT table. Unenhanced MDCT was performed starting from the top of the liver in a cephalocaudal direction. After acquisition of unenhanced liver images, contrast medium with an iodine concentration of 370 mg I/ml (Ultravist 370; Bayer Healthcare) was administered using a power injector (multilevel CT; Medrad). Determination of the scanning delay for arterial phase imaging was achieved using an automatic bolus-tracking technique (CARE Bolus; Siemens). Single-level-monitoring, low-dose scanning (80 kVp, 100 mA) was initiated 10 s after contrast injection. Arterial phase scanning began automatically 12 s after the trigger threshold (100 HU) was reached at the level of the supraceliac abdominal aorta. Dynamic imaging consisted of three phases—arterial, portal, and equilibrium phase.

2.3. MRI protocol

All MRI examinations were performed using a 3.0-T unit (Magnetom Trio a Trim; Siemens) with the combination of a phased-array body coil and spine array coil for signal reception. The following baseline magnetic resonance (MR) images were obtained: fat-suppressed respiratory-triggered T2-weighted turbo spin-echo sequence (TR/TE of 3500–5000/70–85, echo train length of 10, flip angle of 140°, matrix of 320×202, slice thickness of 3 mm); breath-hold T2-weighted turbo spin-echo sequence (2500–4500/103, 140° flip angle, 320×202 matrix, 5-mm slice thickness); T2-weighted half-Fourier acquisition single-shot turbo spin-echo sequence (400–500/100–150, 150° flip angle, 256×166 matrix, 3-mm slice thickness); a breath-hold T1-weighted fast low-angle shot sequence [TR of 172, TE of 2.46 (in phase)/1.22 (out of phase), flip angle of 65°, matrix of 256×208, signal average of

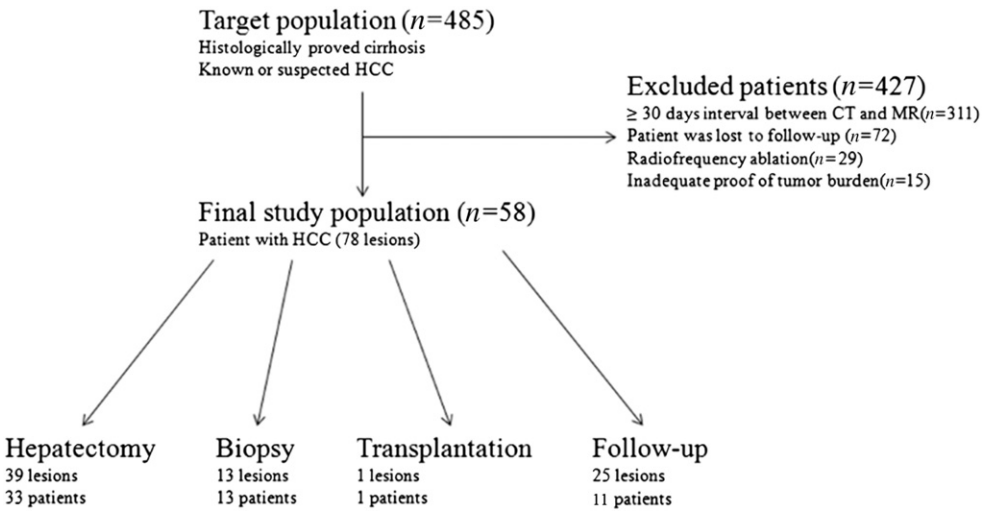

Fig. 1. Flow chart of patient enrollment and proof of tumor burden.