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Original Article

Role of 3-T diffusion-weighted magnetic resonance imaging in differentiation between benign and malignant hepatic lesions

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ABSTRACT

Aim: To evaluate the ability of DWIs to distinguish between benign and malignant focal hepatic lesions (FHLs) using 3 T MR.

Material and methods: A total of 73 FHLs in 48 patients were evaluated. There were 28 benign lesions including 13 hemangiomas (17.8%), 8 hepatic cysts (10.9%), 4 regenerating hepatic nodules (5.4%), 2 adenomas (2.7%) and 1 focal fatty infiltration (1.3%). The others 45 lesions were malignant including 28 hepatocellular carcinomas (38.3%), 15 metastases (20.5%) and 2 cholangiocarcinomas (2.7%). The study used two *b* values (0 and 800 s/mm^2) and the ADC values were calculated.

Results: The mean ADC value for simple liver cysts was $2.58 \pm 0.35 \times 10^{-3}$ mm^2/s, for solid benign lesions was $1.63 \pm 0.41 \times 10^{-3}$ mm^2/s and for malignant lesions was $1.21 \pm 0.38 \times 10^{-3}$ mm^2/s with statistical difference ($p < 0.0001$). We found that the best ADC cutoff value was 1.49×10^{-3} mm^2/s with accuracy of 83.6% in differentiation between the all benign and malignant FHLs. While with exclusion of the cystic hepatic lesions, the best ADC cutoff value was reduced to be 1.35×10^{-3} mm^2/s with accuracy of 78.5%.

Conclusions: DWI can be used to differentiate between the benign and malignant FHLs.

1. Introduction

Confident diagnosis of the focal hepatic lesions (FHLs) is so essential for proper management. Many benign and malignant FHLs have typical radiological features. In clinical practice, improvement in different radiological modalities during the last three decades, particularly the multislice computed tomography (MSCT) and magnetic resonance imaging (MRI) have succeeded to solve and diagnose many indeterminate FHLs with no need of histopathological correlation [1–4]. Recently, the role of MRI and Positron emission tomography-computerized tomography (PET-CT) has proven to have high capability to differentiate between benign and malignant FHLs. Yet some hepatic lesions are still indeterminate with atypical features in spite of the progress in these different imaging modalities.

Diffusion weighted imaging (DWI) is very useful for assessment of FHLs with high tissue contrast and no need to expose the patient to ionizing radiation [5]. The dynamic contrast enhanced and post contrast subtraction MR images during the different phases of contrast injection are so helpful to diagnose the FHLs and determine the post interventional tumor viability as well [6].

Since the 1990s, DWI using single-shot echo-planar imaging was successfully used in the neuro-radiology, particularly in early detection of cerebral ischemic insult [7,8]. Later on, with progress in the MRI techniques, development

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of parallel imaging, high gradient amplitudes and multi-channel coils, DWI expands its clinical role in oncology. Regarding the liver imaging, many studies have proved that DWI is capable to detect and characterize benign and malignant FHLs [9–11]. In the last two decades, many studies were performed concerned with the assessment and validity of DWI in the characterization and detection of FHLs [12–21].

The DWI is based on the measurement of movement and diffusion of the water molecule protons within the imaged soft tissue, within the intra- and extracellular compartments. The DWI depends on the cell membrane integrity and lipophilicity in addition to cellularity within the lesion [22,23]. If the water protons moves freely within the tissues of low cellularity, that will represent facilitated diffusion. While if the movement of the water protons is restricted due to high cellularity of the tissue that will represent restricted diffusion. Therefore, DWIs can be analyzed in two ways, qualitatively, by visual assessment of signal intensity, and quantitatively, by measurement of the apparent diffusion coefficient (ADC). ADC values are calculated from the slope of the line drawn between the *y*-axis (logarithm of signal decay) and *x*-axis (different *b* values) [24]. ADC values are considered the magnitude of water diffusion, and these values are generated and calculated in automatic way using special software. These values are displayed in ADC maps.

Benign and malignant focal lesions have different ADC values, and malignant tumors have a high cellularity and low extracellular space volume, so resulting in impeded water proton diffusion and therefore low ADC values. In contrast, benign lesions are characterized by an increased amount of extracellular matrix with minimal increase in cellular density, resulting in higher ADCs [22,23].

In spite of the large number of studies were performed in liver imaging using DWI, the ADC cutoff values in the differentiation between the benign and malignant hepatic lesions remain unclear and sometime confusing. Most of the previous studies used MR 1.0 or 1.5 T and include hepatic cysts. Our study used 3.0 T MR scanner. The aim of our study was to evaluate the ability of ADC to distinguish between benign and malignant hepatic lesions with and without inclusion of the cystic hepatic lesions.

2. Patients and methods

2.1. Patients

After approval of the institutional review board, this prospective study was done on 48 patients with 73 lesions over a period of 9 months between September 2014 and May 2015. Those patients were referred from the different medical and surgical departments of Cairo University Hospital. Informed consent was obtained from all patients after full explanation of the benefits and risks of the procedure.

2.1.1. Inclusion and exclusion criteria

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(1) Adult patients over the age of 20 years.
(2) The presence of at least one FHL detected by conventional MR, U/S or CT examination and measuring at least 1 cm in maximum diameter.

2.1.1.2. Exclusion criteria.

(1) Patients who had no FHL or had lesion less than 1 cm in diameter.
(2) Patients treated by radiofrequency or chemoembolization.
(3) Patients with contraindications for MR imaging; claustrophobia, pacemaker or metal implants.
(4) Patients with contraindication for contrast material including known allergy and renal insufficiency (glomerular filtration rate <30 mL/min/1.73 m^2).

2.2. Liver MRI imaging protocol

MRI studies were performed on Philips Achieva, Netherland 3.0 T MR unit by using body phased-array coil with patient in supine position. The examinations were performed by professional operator (more than 5 years experience). The MR sequences were performed in order as follows:

1. Unenhanced axial T1-Fast Field Echo (T1-FFE) images. Parameters are repetition time (TR) 2.3/ms, echo time (TE) 10 ms, number of signal averages (NSA) = 2, thickness = 9 mm, gap = 1.5 and matrix 268 × 180.
2. Axial T2-Fast Field Echo (T2-FFE) images. Parameters are repetition time (TR) 750–1000/ms, echo time (TE) > 100 ms, number of signal averages (NSA) = 2, thickness = 9 mm, gap = 1.5 and matrix 308 × 218.
3. 3D T1-weighted isotropic imaging (THRIVE): before contrast injection, parameters are TR 3.3/ms, TE 1.6 ms and flip angle of 10°.
4. Diffusion weighted sequences (Respiratory-triggered protocol using *b* values = 0 and 800 s/mm^2). Diffusion-weighted MR sequences were performed with the single shot echo-planar imaging (EPI) technique. Subsequent measurement of mean apparent diffusion coefficient (ADC) value was done for each FHL.
5. Axial 3D dynamic contrast material enhanced (Gd-DTPA) imaging (Axial 3D T1-weighted isotropic imaging/THRIVE images) was done. Bolus of contrast injection (0.2 mL/kg body weight of Gd-DTPA) was performed followed by flush with 25 ml of sterile 0.9% saline solution. The arterial, portal and delayed phases were scanned at 20 s, 60 s and 5 min after contrast injection respectively. Subtraction images for the arterial and portal phases were performed for all cases.

2.3. Lesion characterization

For benign lesions (hepatic cysts and cavernous hemangiomas) of typical MRI findings, no histopathological confirmation was done, just follow-up with triphasic CT or MR within 6–8 months. The diagnosis of hepatic adenomas was confirmed by their stable typical pattern of contrast enhancement and morphological features on the previous and follow-up studies (within 1–2 years duration).

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