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Is diffusion weighted imaging adding value in diagnosis of focal hepatic lesions? Experience in 50 patients

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KEYWORDS

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Abstract *Introduction:* Diffusion weighted imaging (DWI) offers molecular information that complements the morphologic information obtained with conventional magnetic resonance imaging (MRI) and can reflect the functions and structures of the body without trauma.
Aim of the work: To assess the role of DWI as a routine sequence in a MRI study to help in differentiating liver lesions.
Patients and methods: The study included 50 patients referred to do a MRI study to diagnose and/or to confirm the ultrasonographic or CT findings of focal hepatic lesions. The examination was done on 1.5T superconducting magnet MRI machines; Philips Gyroscan Intera version 12.1.1.2 (Best, The Netherlands) and Siemens Magnetom Avanto (Erlangen, Germany) machine.
Results: All studied patients had a focal hepatic lesion either on top of cirrhotic liver or non cirrhotic liver. DWI was found to be helpful with the routine MRI sequences to reach the diagnosis. The final diagnosis was confirmed by histopathological examination or follow up.
A cutoff value of ADC for benign lesions was found to be 1.25×10^{-3} mm^2/s.
Conclusions: DWI should be included as a basic sequence in the routine MRI study of the liver as it helps in diagnosis and so reaching a final diagnosis or at least trying to narrow the list of differential diagnosis.

Abbreviations: DWI, diffusion weighted imaging; MRI, magnetic resonance imaging; ADC, apparent diffusion coefficient.

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1. Introduction

MRI plays an increasingly important role in the evaluation of patients with liver disease because of its high contrast resolution, lack of ionizing radiation, and the possibility of performing functional imaging sequences. With advances in hardware and coil systems, diffusion weighted imaging (DWI) can now be applied to liver imaging with improved image quality.[1,2]

DWI offers molecular information that complements the morphologic information obtained with conventional MRI, and can reflect the functions and structures of the body without trauma and as an index for assessing the tumor response to treatment.[3–6]

1.1. Principles of DW MRI

DWI exploits the random motion of water molecules. In a totally unrestricted environment, water movement would be completely random, a phenomenon otherwise known as Brownian motion or free diffusion.[7]

Within biologic tissues, the movement of water is not completely random, but rather, is impeded by the interaction with tissue compartments, cell membranes, and intracellular organelles. For purposes of simplification, water movement in tissues may be categorized as intravascular, intracellular, or extracellular (Fig. 1).[1,8]

The extent of tissue cellularity and the presence of intact cell membranes help determine the impedance of water molecule diffusion. Tissue types that have been reported to be associated with impeded diffusion include tumor, cytotoxic edema, abscess, and fibrosis. Tissues with low cellularity or that consist of cells with disrupted membranes permit greater movement of water molecules.[6]

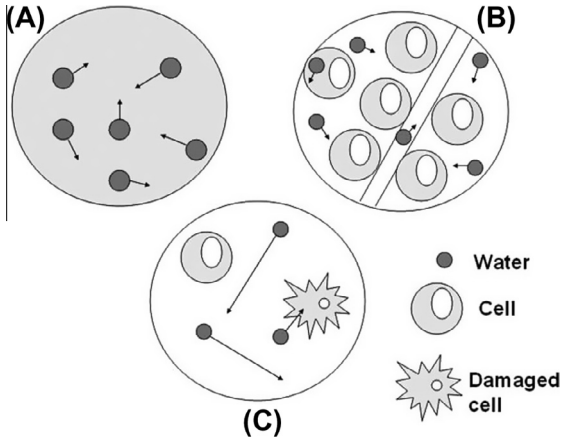

Figure 1 Schematic illustrating water molecule movement. In (A) water molecules in a container alone move randomly (Brownian motion). In (B) highly cellular tissue impedes the movement of water molecules. Their movement can be categorized as intravascular, intracellular, or extracellular. In (C) tissue of low cellularity or with defective cells permits greater water molecule movement.[1]

The spin-echo T2-weighted sequence consists of a 90° radiofrequency (RF) pulse followed by a 180° RF pulse, with the T2 decay related to transverse relaxation. Measurement of water diffusion is possible with the application of a dephasing gradient (diffusion sensitizing gradient) prior to the 180° RF pulse. A symmetric rephasing gradient is then applied after the 180° RF pulse (Fig. 2a). In a simplified model, the effect of the first (dephasing) gradient is cancelled out by the second (rephasing) gradient in tissues with limited or impeded water movement, such as the highly cellular tissue of tumors. Therefore, there is little impact on the overall T2 decay, and the T2 signal of the tissue is maintained. In tissues with unimpeded water movement (low cellularity tissue), water molecules may move a considerable distance between the dephasing and rephasing gradient applications. Consequently, the mobile water molecules will not be fully rephased, resulting in a reduction in overall T2 signal intensity (Fig. 2b).[1,6]

1.2. Choice of b values and sequence optimization

Because of the relatively short T2 relaxation time of the normal liver parenchyma, the b values used for clinical imaging are typically no higher than 1000 s/mm^2. Applying a small diffusion weighting of b less than 100–150 s/mm^2 nulls the intrahepatic vascular signal, creating the so-called black-blood images, which improve the detection of focal liver lesions (Fig. 3) while higher b values ($\geqslant$500 s/mm^2) give diffusion information that helps in focal liver lesion characterization. Hence, when performing DW MR imaging in the liver, it is advantageous to perform imaging by using both lower and higher b values (e.g., $b \geqslant 50$, $b \geqslant 100$, and $b \geqslant 500$ s/mm^2).[9–12]

1.3. Qualitative visual assessment

Visual assessment is helpful for disease detection and characterization by observing the differential signal attenuation between tissues on DW MRI. Cellular tissues will demonstrate restricted diffusion (high signal intensity) and lower ADC values.[1]

1.4. Quantitative analysis of DWI findings and ADC

The ADC represents the slope (gradient) of a line that is produced when the logarithm of relative signal intensity of tissue is plotted along the y-axis versus b values along the x-axis thereby linearizing the exponential decay function. Quantitative analysis of diffusion-weighted imaging findings can be performed only if at least two b values are used for imaging.[13–15]

The analysis of ADC is an automated process that is available as an application on most scanners or on a workstation. The ADC can then be displayed as a parametric map and essentially reflects differences in tissue diffusivity at different b values. ADC measurements are then recorded