The Egyptian Journal of Hospital Medicine (October 2017) Vol.69 (2), Page 1823-1827

Role of Diffusion Weighted MRI Imaging in Detection of Liver Metakstases

Khalid E. Allam, Mennatallah H. Shalaby, Israa A. Moulood
Department of Diagnostic Radiology, Faculty of Medicine, Ain Shams University

ABSTRACT

Background: diagnosis of liver metastases is of essential importance in the staging of patients with a known primary tumor. **Aim of the work:** The study aimed to evaluate role of DWI in diagnosis of liver metastasis. **Patients and methods:** twenty patients were included in this study. The cases were evaluated over 6 months at Ain Shams University Hospital with a 1.5 Tesla Phillips (MR System Achieva) whole body imager. Results: in the sample of the study which was composed of 20 patients there were two patients who presented with negative lesion in DW MRI with sensitivity 100%, specificity 90% and accuracy 95%.

Conclusion: DWI alone performs equally well as Gd-MRI in the diagnosis of liver metastases. In cases where gadolinium injection is not allowed, dynamic contrast-enhanced imaging can be replaced by a protocol based on unenhanced T1- and T2-weighted imaging combined with DWI. Recommendations: Further studies on larger scale of patients are needed to confirm the results of the study.

Keywords: diffusion, weighted MRI imaging, liver metastasis.

INTRODUCTION

Liver cancer is one of the leading causes of all cancer related deaths. In fact, the secondary hepatic malignancies (liver metastases) are more common than the primary ones. Almost all solid malignancies can metastasize to liver (1). Accurate diagnosis of liver metastases is essential for appropriate management of these patients. Multiple imaging modalities, including ultrasound, computed tomography (CT), positron emission tomography and MRI are available for the evaluation of patients with suspected or known liver metastases (2).

There is growing interest in the applications of diffusion-weighted-imaging (DWI) in oncologic area. DWI has important advantages because it does not require contrast medium, a very quick technique and it provides qualitative and quantitative information that can be helpful for tumor assessment (3). DWI is an imaging technique which provides tissue contrast by the measurement of diffusion properties of water molecules within tissues. Diffusion is expressed in an apparent diffusion coefficient (ADC), which reflects the diffusion properties unique to each type of tissue (4).

Both low and high b-value DWI are effective in suppressing vascular structures that may mimic or obscure liver lesions, but low b-value DWI provides a higher signal-to-noise ratio, is less prone to cardiac motion-induced signal loss and suffers less from eddy current-induced distortions. Previous studies have already shown that low b-value DWI is more sensitive than high *b*-value DWI in detecting malignant liver lesions (5). Tumors are frequently more cellular than the tissue from which they originate and thus appear to be of relatively high signal intensity (restricted diffusion) at DWI (6). DWI is being applied for the detection of liver metastases. In the liver, low b-value images (e.g., b = 50–150 s/mm2) that suppress the high-signal flow from the hepatic vessels, resulting in black blood images, have been found to be useful for lesion detection. Metastases appeared as high-signal-intensity foci at DWI. Some of the challenges encountered in DWI of the liver are cardiac motion and susceptibility artifacts that can obscure or diminish visualization of the left lobe.

The susceptibility effects may result from air in the adjacent stomach or colon. Artifacts resulting from cardiac motion can be reduced by triggered acquisition by ECG or a peripheral pulse unit, thus improving image quality and signal-to-noise ratio in the left lobe of the liver. Images may also be acquired with the aid of respiratory triggering to minimize inadvertent breathing motion. However, these techniques increase the image acquisition time, which can render the examination more susceptible to bulk motion (6). This study aimed to evaluate the role of DWI in diagnosis of liver metastasis.

PATIENTS AND METHODS

Twenty patients were included in this study. The cases were evaluated over 6 months duration at Ain Shams University Hospital with a 1.5 Tesla Phillips (MR System Achieva) whole body imager.

Inclusion Criteria

Received: 24 / 7 /2017
Accepted:3 /8 /2017
DOI : 10.12816/0040608

Any patient who is known to have proven primary extra hepatic cancer of any age with proved metastases to liver by history ,examination ,investigation and other imaging's and MRI sequences (T1,T2,postcontrast MRI).

Exclusion Criteria

1. Unstable clinical status.
2. Contraindications to MR imaging: claustrophobia, patients with pace maker or metal implants and patient with risk of nephrogenic systemic fibrosis.
3. Patients presented with any type of primary liver cancer.

Patient's preparation

All patients were submitted for clinical examination, U/S &/or MSCT. MRI was done after written consent taken from the patients.

The patients were fasting for at least 4 hours & cannulated before examination.

MRI examination

Conventional MRI, post Gd-DTPA dynamic and diffusion MR imaging were performed, the diffusion images with ADC values were reviewed.

A. Conventional MR protocol used (Table 1)

B. Dynamic study

Dynamic study was performed after bolus injection of 0.1mmol/kg body weight of Gd-DTPA at a rate of 2ml/s, flushed with 20ml of sterile 0.9% saline solution from the antecubital vein. Dynamic imaging using T1 THRIVE (High Resolution Isotropic Volume Examination) technique was performed in triphasic way [arterial phase (16-20 sec.), porto-venous phase (45-60 sec.) and delayed equilibrium phase (3-5 min.) after administration of contrast media.

C. Diffusion study

Respiratory-triggered fat-suppressed single-shot echo planar DW imaging was performed in the transverse plane with tri-directional diffusion gradients by using b values 0, 200 & 800 sec/mm2 to increase sensitivity to cellular packing. Parallel imaging with generalized auto- calibrating partially parallel acquisition (GRAPPA) with an acceleration factor of two was applied to improve image quality.

The other parameters were as follows: repetition time (TR) ≥1880 m sec, echo time (TE) = 70 m sec, number of excitations (NEX)=3, matrix 256x256 with a field of view as small as possible with 52% rectangular field of view, slice thickness 7-8mm, slice gap 1-2mm, scan time 3-4 min.

ADC calculation:

The mean ADC of each focal lesion detected is measured by drawing a region of interest over the lesion. The ADC was measured twice and the two measurements were averaged. To ensure that the same areas were measured, regions of interest were copied and pasted from DW images to ADC maps.

Image Interpretation on D W Echoplanar Sequences:

Criteria of malignant lesions:

- On b (200) : hyperintense signal is seen acquired by the lesion
- On b (800): persistent hyperintense signal
- ADC value is low(less than 1.1mm/s)

The study was approved by the Ethics Board of Ain Shams University.

Statistical analysis

Data were analyzed using Statistical Program for Social Science (SPSS) version 18.0. Quantitative data were expressed as mean ± standard deviation (SD). Qualitative data were expressed as frequency and percentage. Probability (P-value) was considered significant if it is <0.05, highly significant if <0.001 and insignificant if >0.05.

RESULTS

Twenty patients were included in this study. The cases were evaluated over 6 months duration at Ain Shams University Hospital with a 1.5 Tesla Phillips (MR System Achieva) whole body imager using a body phased array synergy coil.

As regard the age of the patients, it ranged from 35 years to 73 years with median age of 55 years. 20 patients were included in the study, 9 of them (39%) were male and 11 were female (61%) (Fig. 1).

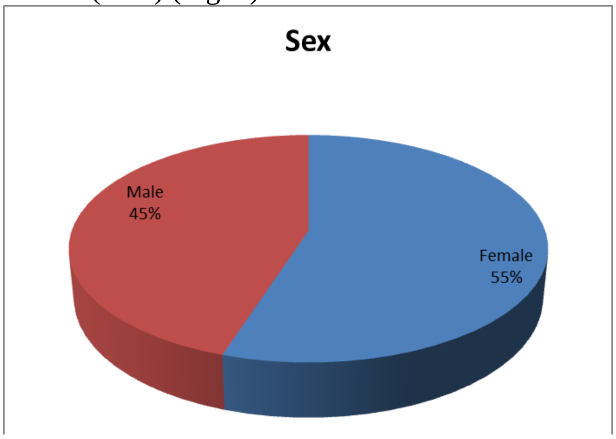

Figure 1: Pie chart showing sex distribution of the study group.

Table 1: pre-contrast imaging included parameters.

	TR (m sec)	TE (m sec)	Matrix size	Slice thickness (mm)	Slice gap (mm)	FOV (mm)
T1W	10	4.58	179×320	7 - 8	1 - 2	355
T2W	≥ 445	26 - 28	200×240	7 - 8	1 - 2	365
T2 SPAIR	≥ 400	80	204×384	7 - 8	1 - 2	365
In phase /out phase	75 - 100	4.6 (IP)& 2.3 (OP)	143×240	7 - 8	0	345
T2	520	200	235×384	7 - 8	1 - 2	375

Table 2: types of primary lesion distribution of the study group

Type of primary lesion	No.	%
Colon ca.	7	35
Gastric ca.	3	15
Rectal ca.	2	10
Urinary bladder ca.	2	10
melanoma	1	5
Anorectal ca.	1	5
Breast ca.	1	5
Colorectal ca.	1	5
Endometrial ca.	1	5
Rectosegmoid ca.	1	5
Total	20	100

Metastatic lesions showed restricted diffusion evidenced by increased signal on increasing the b-values from 0 to 800 and low signal on ADC maps.

Of the 20 cases of our study there were 15 cases having multiple liver metastases and 5 cases with single liver metastases.

Table 4: number of metastasis distribution of the study group .

True number of metastasis	No.	%
Multiple	15	75
single	5	25
Total	20	100

Table 5: diagnostic Performance of metastasis in DWI Discrimination of true number of metastasis.

Sen.	Spe.	PPV	NPV	Accuracy
100.0 %	90.0 %	90.9 %	100.0 %	95%

In the sample of the study which composed of 20 patients there were two patients who presented with negative lesion in DW MRI.

The first patient was a known primary colon cancer who had single hypovasculer metastases in right lobe segment 8, the lesion was missed in DW- MRI .

The second patient was a known case of primary breast cancer she had two lesions in right lobe missed in DWI. Lesions less than 1cm composed (15%),while lesions more than 1cm composed (85%).

DISCUSSION

Diagnosis of liver metastases is of essential importance in the staging of patients with a known primary tumor [7]. MRI is considered to be the best imaging technique for diagnosing liver metastases, using either extracellular gadolinium compounds or liver specific contrast media. However, with the recent findings of nephrogenic systemic fibrosis (NSF) related to gadolinium contrast administration, the use of these compounds has been limited in patients with impaired renal function. As an alternative to gadolinium, super paramagnetic iron oxide can be used, but it requires T2 imaging pre- and post-injection, which in most cases is more time consuming than gadolinium based imaging [8]. Furthermore, iron oxide based liver specific contrast media have been withdrawn from the market in many countries. Although care should be taken when comparing different studies on liver DWI because of the variability of used techniques (i.e. hardware differences, different b-values, respiratory triggering techniques, etc.), recent literature has shown promising results for DWI of the liver.

Adding DWI sequences to the examination raises the diagnostic accuracy of liver MRI, without the need for added contrast material [9]. There have been many studies that investigated DWI in comparison to other MRI sequences for many types of liver lesions [10-13]. In this study we evaluated DWI as a standalone sequence in detecting and characterizing hepatic metastases and we investigated if there were benefits of using DWI. DWI sequence only takes about 4 min to perform, this could yield higher efficacy [14]. The results of our study showed that the sensitivity was 100% and the specificity was 90% . In a study comparable to ours **Hardie *et al*.** [13] found similar accuracies of 0.90 and 0.92 from two observers for the diagnosis of hepatic metastases. **Breugel *et al*.** [12] evaluated 118 hepatic metastases and found accuracies of 0.91 and 0.90 for DWI from two observers. This confirms the results of **Hardie *et al*.** [13].

They found a sensitivity of 66% for DWI which is lower than we found (100.0%) but their specificity (90%) is similar to ours (90%). However, most studies compare DWI to other sequences, which do not reflect daily clinical practice. In the diagnosis of liver metastases on MRI, a set of multiple sequences is used. Because of time restrictions, radiologists have to make a choice between different sequences and contrast materials [15].

Whenever possible DWI should be included in the imaging protocol [15].

This study has limitations. Firstly, only a small number of hepatic metastases and none of the lesions were histopathologically confirmed. We used history other imaging and follow-up approach for diagnosing liver lesions, which limits the probability of misclassification of lesions, where upon the readers had to draw the lesion. One of the main limitations of our study was the inability to use a surface coil for the acquisition of DWI data. The use of the body coil significantly decreases the acquired signal and signal –to-noise ratio, we tried to overcome such limiting factor by using a large b factor (800 sec/mm²). Although it provides more precise evaluation of ADC values, however image quality is diminished to some extent [15]. **Aube *et al*.** [16] have stated that the use of surface coils, by increasing the amount of acquired signal, should provide significant results using higher b values (>400 sec/mm²). **Ichikawa *et al*.**[10] had found that on the use of large b factor in abdominal diffusion weighted images, image quality will be greatly diminished. This is further complicated by the fact that the liver has short T2 relaxation time; because DW sequences are T2-weighted sequences, there is already inherent loss of signal.

Laghi *et al*. [17] results had showed that image quality was decreased with the increase of b values: at low b values, the anatomy of upper abdominal organs was easily recognized, whereas, at high b values, the same organs could not be adequately assessed unless the images were compared with those obtained with low b values Another factor that does affect the image quality in our study was that the images have low spatial resolution due to the use of single shot technique which has greatly limited the detection of small lesions. So from the previously mentioned situations, we may say that the echoplanar images with a higher spatial resolution is still important for detection of small lesions and that also the single shot echoplanar sequence (which was used in our study) produces a distortion artifact in addition to its handicapped ability in detection of sub diaphragmatic and lateral segment focal lesions especially small and ill-defined lesions.

Taouli *et al.* [18] have stated that their study is limited by the use of single shot ehoplanar imaging which had a low spatial resolution and low signal to noise (SNR) ratio which had greatly influenced the lesions detection and therefore the infracentimeric lesions were not evaluated. Pulse triggering of single-shot sequences leads to significant reduction of motion related artifacts on DW images of the abdomen and provides more accurate and reproducible ADC values [19].

The use of only two b values in our study has advantage that it shortened the examination duration and takes less time in lesions evaluation, but on the other hand it is less sensitive in lesions detection and ADC values estimation than on using multiple b values.

Laghi *et al.* [17] research, have performed separation of the sequence calibration cycles and the image acquisition pulses into two breath holds which is a special feature that may not be available with other MR imaging systems. Thus, the acquisition duration would be prolonged to about 25 seconds for 70 heartbeats per minute, which would exceed tolerable breath-hold duration for most patients.

From the previously discussed issues, we may find that DW MR imaging of the abdomen is still a technical challenge. Problems arise from the stronger motion influences in the abdomen that are caused by breathing and pulsations and by the reduced (SNR) for tissues with short T2, such as muscle and liver.

However, in spite of the already mentioned limitations, DWE technique has the strength to evaluate hepatic focal lesions in addition to conventional MRI, with a more precise differentiation for the lesion nature, which is a very important criterion that unmasks the cost-effectiveness of such technique in limiting the need for contrast agent’s use in most of the cases.

CONCLUSION

DWI alone performs equally well as Gd-MRI in the diagnosis of liver metastases. In cases where gadolinium injection is not allowed, dynamic contrast-enhanced imaging can be replaced by a protocol based on unenhanced T1- and T2-weighted imaging combined with DWI.

REFERENCES

1) **Golubnitschaja O and Sridhar KC(2016**): Liver metastatic disease: new concepts and biomarker panels to improve individual outcomes. Clin. Exp. Metastasis, 33(8):743-755.
2) **Chandarana H and Taouli B(2010):** Diffusion-weighted MRI and liver metastases. Magn Reson Imaging. Clin. N. Am.,18 (3):451-64.
3) **Bozgeyik Z, Onur MR and Poyraz AK(2013):**The role of diffusion weighted magnetic resonance imaging in oncologic setting. Quant. Imaging Med. Surg., 3(5):269-278.
4) **Kele PG, van der Jagt EJ (2010):** Diffusion-weighted imaging in the liver World J. Gastroenterol.,16(13):1567-1576.
5) **Kwee TC and Takahara T(2011):** Diffusion-weighted MRI for detecting liver metastases: importance of the b-value. Eur. Radiol., 21(1):150-159.
6) **David J (2007):**Diffusion weighted MRI in the body: applications and challenges in oncology. American Journal of Roentgenology,188: 1622-1635.
7) **Bachir T and Dow-Mu K (2010):**Diffusion-weighted MR Imaging of the liver. RNSA Radiology, 254: Issue 1:Pages 47-66.
8) **Ichikawa T, Hachiya J, Nitatori T and Araki T(1998)** Diffusion-weighted MR imaging with a single-shot echoplanar sequence: detection and characterization of focal hepatic lesions. AJR., 170:397–402.
9) **Chiu FY and Jao JC(2005):** Effect of intravenous gadolinium-DTPA on diffusion-weighted magnetic resonance images for evaluation of focal hepatic lesions. J. Comput. Assis. Tomogr., 29(2):176-180.
10) **Namimoto T, Yamashita Y, Sumi S, Tang Y *et al.* (1997):** Focal liver masses: characterization with diffusion-weighted echo-planar MR imaging. Radiology, 204:739–744.
11) **Vossen JA, Buijs M, Liapi E, Eng J, Bluem *et al.* (2008):** Receiver operating characteristic analysis of diffusion-weighted magnetic resonance imaging in differentiating hepatic hemangioma from other hypervascular liver lesions. J. Compu.t Assist. Tomogr., 32:750–756.
12) **Bruegel M, Gaa J, Waldt S *et al.* (2008):** Diagnosis of hepatic metastasis: comparison of respiration-triggered diffusion-weighted echo-planar MRI and five T2-weighted turbo spin-echo sequences. AJR., 191:1421–1439.
13) **Hardie AD, Naik M, Hecht EM *et al*. (2010):** Diagnosis of liver metastases: value of diffusion-weighted MRI compared with gadolinium-enhanced MRI. Eur. Radiol., 20:1431–1441.
14) **Matsuo M, Kanematsu M, Itoh K *et al.* (2001):** Detection of malignant hepatic tumors: comparison of gadolinium- and ferumoxide-enhanced MR imaging. AJR., 177:637–643.
15) **Low RN and Gurney J (2007):** Diffusion-weighted MRI (DWI) in the oncology patient: value of breath hold DWI compared to unenhanced and gadolinium-enhanced MRI. J. Magn. Reson. Imaging, 25:848–858.
16) **Aube C, Racineux PX, Lebigot J, Oberti F *et al*. (2004):** Diagnosis and quantification of hepatic fibrosis with diffusion weighted MR imaging: preliminary results. J. Radiol., 85 (3): 301-306.
17) **Laghi A, Catalano C, Assael FG, Panebianco V *et al.*(2001):** Diffusion weighted echo – planar sequences for the evaluation of the upper abdomen: technique optimization. Radiol. Med. (Torino), 101 (4): 213-218.
18) **Taouli B, Valerie V, Erik D *et al.* (2003):** Evaluation of liver diffusion Isotropy and characterization of focal hepatic lesions with two single shot echo planar MR imaging sequences: Prospective study in 66 patients. Radiology, 226: 71-78.
19) **Yoshimitsu K, Irie H, Aibe H, Tajima T*et al*. (2004):** Pitfalls in the imaging diagnosis of hepatocellular nodules in the cirrhotic and non cirrhotic liver. Intervirology, 47 (3-5): 238-251.