International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2022): 7.942

The Role of Diffusion - Weighted Magnetic Resonance Imaging in Characterizing Focal Liver Lesions

Dr. Bhavya Tak1, Dr. Subhash Saini[2], Dr Ritesh Dhuria[3]

[1]Resident Department of Radiodiagnosis JLN MC Ajmer, India

[2]Assistant Professor Department of Radiodiagnosis JLN MC Ajmer, India

[3]Resident Department of Radiodiagnosis JLN MC Ajmer, India

Abstract: ***Focal liver lesions (FLL) present significant diagnostic challenges in clinical practice, necessitating accurate differentiation between benign and malignant entities. This paper reviews the utility of diffusion - weighted magnetic resonance imaging (DW - MRI) and apparent diffusion coefficient (ADC) measurements in evaluating hepatic masses. By synthesizing current literature, we aim to elucidate the diagnostic potential of DW - MRI and its implications for patient management.***

Keywords: Liver Lesions, DW - MRI, ADC Measurements, Hepatic Masses, Diagnostic Imaging, Radiology, Radiodiagnosis, Imaging, Focal Liver Lesions

1. Introduction

Focal liver lesions are increasingly identified due to advancements in imaging technologies. The accurate characterization of these lesions is crucial for determining appropriate management strategies. Among various imaging modalities, DW - MRI has emerged as a valuable tool for assessing hepatic masses due to its ability to measure water molecule diffusion within tissues, providing insights into tissue microstructure and cellularity

Purpose of Study

Focal liver lesions (FLL) pose a frequent challenge encountered by gastroenterologists and hepatologists in clinical practice. The burgeoning utilization of imaging modalities has notably escalated the identification of incidental FLL cases. Hence, it becomes imperative to not only focus on the diagnosis of malignant liver lesions but also to meticulously evaluate benign solid and cystic liver lesions, underscoring the comprehensive nature of lesion characterization in clinical management. This study investigates the role of DWI in distinguishing between malignant and benign hepatic lesions through ADC value calculations.

Limitations:

- The study's relatively small sample size and single - center design may limit the generalizability of findings regarding DWI and ADC measurements for focal liver lesion evaluation.
- We did not include pediatric patients in our study due to the limited availability of pediatric inpatient and outpatient data.
- Only common hepatic lesions were studied. FNH (2 cases), hepatic adenoma (1 case), and cystic metastasis (2 cases) were excluded from the study due to their low numbers.
- Lack of histopathological confirmation for all lesions is a potential limitation, as some were characterized based solely on imaging features and clinical follow - up.
- Future studies with larger patient cohorts and diverse geographical representation are needed to validate and enhance the diagnostic performance of DWI and ADC measurements.

2. Review of Literature

Several studies have highlighted the diagnostic potential of DW - MRI in the evaluation of focal liver lesions. Bruegel and Rummeny [2] concluded that DW - MRI is more sensitive than T2 - weighted MRI and at least as accurate as superparamagnetic iron oxide (SPIO) or gadolinium - enhanced MRI for the detection of hepatic metastases. Miller et al. [8] reported that DW - MRI is useful in distinguishing benign & malignant hepatic lesions, while Kilickesmez et al. [3] demonstrated the value of ADC measurement in discriminating focal benign and malignant hepatic masses. The liver, being a vital organ, is susceptible to a spectrum of both benign and malignant focal liver lesions (FLL), encompassing primary and secondary origins. The advent of advanced imaging modalities such as ultrasonography (USG), triple - phase computed tomography (CT), and magnetic resonance imaging (MRI) has substantially augmented the detection rate of focal liver lesions, heralding a paradigm shift in diagnostic capabilities. [4]

DW - MRI detects microscopic motion of water molecules within tissues and develops contrast by applying field gradients during the MRI pulse sequence that sensitize the readout signal to losses from this motion [5].

The value of ADC shows how precipitous a decrease in signal intensity occurs with increasing gradient strength in a given ROI. With a monoexponentially fit, the ADC value is

defined as the slope of the logarithmic decrease in signal intensity between two or more b values.
ADC values are generated on a pixel - by - pixel basis, usually expressed as mm^2/s.

The minimum, maximum, and mean values can be measured, with the following equation:

$$ADC = \sum_{i=1}^{n} \frac{-\ln(S_i/S_0)}{b_i}$$

bi =diffusion gradient value S_i = Signal intesity of the I TH image S_0 = signal intensity of the first image

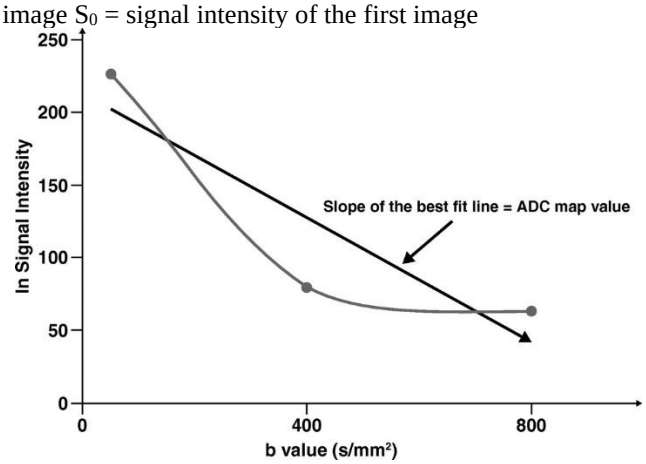

Figure 1: Graph shows apparent diffusion coefficient (ADC) map value calculated by fitting linear regression line assuming monoexponential fit of signal intensities versus different b values on diffusion - weighted images. ADC value = negative of slope of fitted line. ADC map values are generally higher, i. e., slope is steeper, for benign than for malignant tumors. [6]

Clinical Applications of DWI

Central Nervous System:
- DWI in Evaluation of Cerebral Infarction
- DWI in Brain Tumors:

Other Oncological Applications:
- Tumor Detection:
- Tumor Characterization:

3. Materials and Methods

Study Design: Observational study
Duration: June 2022 to June 2024
Setting: Department of Radiology, JLN Hospital Ajmer
Study Population: 83 patients (57 males, 26 females) with focal liver lesions
Inclusion Criteria: OPD/IPD/ICU patients with clinically, radiologically, or histopathologically diagnosed focal liver lesions

4. Discussion

Our study demonstrated the value of ADC measurement in discriminating between benign and malignant hepatic lesions -

- Patient Demographics In the present study, a total of 83 patients with focal liver lesions were evaluated.
- The study population comprised 57 males (68.7%) and 26 females (31.3%), indicating a significant gender disparity, with males accounting for more than two - thirds of the cohort.
- The age distribution of the study participants ranged from 20 to 86 years, with a mean age of 52.4 ± 13.2 years.
- The most common liver lesions were hepatocellular carcinoma (HCC) (21 cases, 25.3%), hemangioma (19 cases, 22.9%), hepatic cysts (14 cases, 16.9%), liver abscess (10 cases, 12.0%), hydatid cysts (10 cases, 12.0%), and metastasis (9 cases, 10.8%).
- Imaging findings and ADC values were calculated for each focal liver lesion in our study.

L**iver abscesses**, which are benign in nature, also demonstrated diffusion restriction, with low ADC values (mean: 841.10 × 10^ - 6 mm^2/s). Therefore, we have not included the ADC values of liver abscess in the calculations and analysis.

The lesions were:
1) Benign hepatic lesions (n =43): Simple cyst (n=14), hemangioma (n=19), hydatid cyst (n=10) and abscess (n=10).
2) Malignant lesions (n=30): Hepatocellular carcinoma (HCC) (n=21) and metastasis (n = 9).

Lesions characterization of DWI sequence –
High signal on DWI and corresponding low ADC value considered diffusion restriction.
High/Iso intense signal on DWI and corresponding high ADC value suggests no diffusion restriction.

Table: Mean ADC values of various focal hepatic lesions in our study

Diagnoses	Mean ADC values (x 10^{ - 3} mm^{2} /sec)	Std. Deviation	Range of ADC value (x 10^{ - 3} mm^{2} /sec)
Abscess	0.841	0.02	0.812 – 0.896
HCC	0.761	0.03	0.702 – 0.799
Metastasis	0.776	0.05	0.720 – 0.850
Hemangioma	2.085	0.12	1.870 - 2.300
Hepatic cyst	3.120	0.16	2.900 - 3.400
Hydatid cyst	2.965	0.09	2.800 - 3.100

All the liver lesions were divided into benign* and malignant groups, and the mean ADC for each group was calculated.
Benign* lesions – Hemangioma, Simple hepatic cyst and Hydatid cyst.
Malignant lesions – HCC and Hepatic Metastasis.

Disease entity	Mean ADC value (x10^{ - 3} mm^{2} /sec) ± SD
Benign*	2.626 +/ - 0.507
Malignant	0.765 +/ - 0.038

Diagnosis	Mean_ADC	Std_Dev	Sample_Size	95% confidence interval for mean		Minimum and Maximum ADC values
				CI_Lower	CI_Upper	
Abscess	0.841	0.02	10	0.828604099	0.853395901	0.812 – 0.896
HCC	0.761	0.03	21	0.748169024	0.773830976	0.702 – 0.799
Metastasis	0.776	0.05	9	0.743333934	0.808666066	0.720 – 0.850
Hemangioma	2.085	0.12	19	2.031042411	2.138957589	1.870 - 2.300
Hepatic cyst	3.12	0.16	14	3.036188415	3.203811585	2.900 - 3.400
Hydatid cyst	2.965	0.09	10	2.909218447	3.020781553	2.800 - 3.100

Parameter	Kim et al.,	Taouli et al.,	Demir et al.,	Bruegel et al.,	Parikh et al., [10]	Vergara et al., [13]	Reza Javadrashid et al.,
No of patients/lesions	126/79	66/52	30/41	102/204	53/211	26/51	93/118
b values (sec/mm²)	0, 846	0, 500	0, 1000	50, 300, 600	0, 50, 500	50, 200, 400, 500, 700, 850	0, 1000
ADC values (in 10 - 3 mm2/s)							
Metastases	1.06 - 1.11	0.94	0.79 + 0.11	1.22	1.5	1.03	0.49 - 1.31
HCC	0.097 - 1.28	1.33	0.90 + 0.10	1.05	1.3	1.08	0.86 - 1.04
Hemangioma	2.042 - 2.10	2.95	2.46 + 0.21	1.92	2.04	1.68	0.85 - 2.86
Cyst	2.91 - 3.03	3.63	3.05 + 0.26	3.02	2.54	NA	NA
Adenoma/FNH	NA	1.75	Na	1.4	1.49	1.3	0.96 - 1.29
Benign lesions*	2.49	2.45	2.57 ± 0.26	NA	2.19	1.54	1.58±0.35
Malignant lesions	1.01	1.08	0.86 ± 0.11	NA	1.39	1.04	0.87 ± 0.16
ADC cut - off*	1.6	1.5	NA	1.63	1.6	1.28	1.1
Sensitivity%*	98	84	NA	90	74	84	97.6
Specificity %*	80	89	NA	86	77	84	98.7

Table - (*Represents ADC values determined excluding abscesses.) Various published studies

The mean ADC value for malignant FHLs closely paralleled that reported by Reza Javadrashid et al. (2020). Conversely, for benign FHLs, our mean ADC value aligned closely with those proposed by Taouli B (2003) and Kim (1999).

In our investigation, we assessed signal intensity changes across DWI sequences using b - values of 50 s/mm², 500 s/mm², and a high b - value of 1000 s/mm². While high b - value DWI may encounter challenges like suboptimal signal - to - noise ratio and artifacts, it effectively facilitated the differentiation of malignant FHLs from hemangiomas and cysts: malignant lesions exhibited high signal intensity due to restricted water molecule diffusion, whereas benign lesions typically displayed decreased signal intensity with increasing b - values, attributed to their higher fluid content. Notably, some hemangiomas exhibited persistently high signal intensity in certain areas.

Using mean ADC values of 2.626 x 10 - 3 mm²/sec for benign FLLs (excluding abscesses) and 0.765 x 10 - 3 mm²/sec for malignant FLLs, with ADC ranges of 1.8 to 3.4 x 10 - 3 mm²/sec for benign disease (excluding abscesses) and 0.7 to 0.8 x 10 - 3 mm²/sec for malignant disease, our study successfully differentiated benign from malignant lesions.

However, hepatic abscesses exhibited lower ADC values with a mean of 0.8 x 10 - 3 mm²/sec, overlapping with ADC values seen in malignant FLLs. In such cases, clinical and classical imaging features from MRI and CT played a crucial role in distinguishing abscesses from malignant FLLs.

5. Results

The study demonstrates significant differences in ADC values between benign and malignant hepatic lesions. Key findings include:

1) Malignant lesions consistently showed lower ADC values (mean: 0.765 × 10^ - 3 mm²/sec)
2) Benign lesions (excluding abscesses) demonstrated higher ADC values (mean: 2.626 × 10^ - 3 mm²/sec)
3) The differences were statistically significant ($p \leq 0.05$)
4) Liver abscesses showed unique diffusion characteristics, requiring comprehensive evaluation

6. Summary & Conclusion

In conclusion, the present study highlights the valuable role of DWI and ADC measurements in the comprehensive evaluation of focal liver lesions. The distinct diffusion characteristics and ADC values observed between benign and malignant lesions underscore the utility of these quantitative MRI techniques in the accurate characterization and differentiation of hepatic masses. Integrating DWI and ADC mapping into the multimodal imaging approach can contribute to improved diagnostic accuracy and informed clinical decision - making, ultimately enhancing patient care.

DW - MRI offers significant advantages in the evaluation of focal liver lesions through its ability to quantify diffusion characteristics. Continued research is essential to refine

imaging protocols and improve diagnostic accuracy, ultimately enhancing patient care.

References

[1] Albiin N. MRI of Focal Liver Lesions. Curr Med Imaging Rev.2012; 8 (2): 107 - 116. doi: 10.2174/157340512800672180
[2] Bruegel M, Rummeny EJ. Hepatic metastases: use of diffusion - weighted echo - planar imaging. Abdom Imaging.2010; 35 (4): 454 - 461. doi: 10.1007/s00261 - 009 - 9566 - 3
[3] Kilickesmez O, Bayramoglu S, Inci E, Cimilli T. Value of apparent diffusion coefficient measurement for discrimination of focal benign and malignant hepatic masses. J Med Imaging Radiat Oncol.2009; 53 (1): 50 - 55. doi: 10.1111/j.1754 - 9485.2009.02038. x
[4] Marrero JA, Ahn J, Reddy KR. ACG clinical guideline: the diagnosis and management of focal liver lesions. The American journal of gastroenterology.2014; 109 (9): 1328.
[5] O'Flynn EA, DeSouza NM - Breast cancer research: BCR (2011) Functional magnetic resonance: biomarkers of response in breast cancer. https: //openi. nlm. nih. gov/detailedresult?img=PMC3109577_bcr2815 - 4 6. Ty K. Subhawong et. al Insights into Quantitative Diffusion - Weighted MRI for Musculoskeletal Tumor Imaging https: //doi. org/10.2214/AJR.13.12165
[6] Miller FH, Hammond N, Siddiqi AJ, et al. Utility of diffusion - weighted MRI in distinguishing benign and malignant hepatic lesions. J Magn Reson Imaging.2010; 32 (1): 138 - 147. doi: 10.1002/jmri.22230