Journal of Cardiovascular Disease Research

ISSN: 0975-3583, 0976-2833 VOL13, ISSUE 07, 2022

Original Research Article

"ROLE OF DIFFUSION WEIGHTED MAGNETIC RESONANCE IMAGING IN EVALUATION OF HEPATIC FOCAL LESIONS IN A TERTIARY CARE HOSPITAL"

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ABSTRACT:

Background: Diffusion weighted imaging (DWI) is another mechanism for developing image contrast and relies on changes in the diffusion properties of water molecules in tissues.[2] Diffusion is a physical property, which describes the microscopic random movement of (water) molecules driven by their internal thermal energy.

Objectives:

• To detect and characterize focal liver lesions.

• To differentiate of benign from malignant liver lesions.

• To differentiate liver metastasis from primary liver lesions.

MATERIAL & METHODS: Study Design: A prospective hospital based observational study. **Study area:** Department of Radiodiagnosis, NRI Institute of Medical Sciences, Vishakapatnam. **Study Period:** Jan 2021 – Feb. 2022. **Study population**: Patients attending the department of Radiodiagnosis, NRI Institute of Medical Sciences, Vishakapatnam. **Sample size:** 30 patients with focal liver lesions. **Sampling method:** Simple random method. **Study tools and Data collection procedure:** All patients referred to the department of Radio diagnosis. Patients of all age groups referred to MRI clinically suspected of focal liver lesions. Patients with indeterminate lesions detected on USG or CT.

Results: The number of malignant FLLs detected with DWI (62 out of 63 – 98.4%) was highly significant than that detected with T2 WI (P <0.001). There was no significant difference noted between DWI and T2 WI in detection of benign FLLs may be due to most of benign lesions were more than 2cm in size and benign lesions consisted only cystic lesions and hemangiomas, and no solid benign lesions (FNH and adenoma) were studied.

CONCLUSION: From our study it can be concluded that the use of DWI was superior for the detection of malignant hepatic lesions than the use of T2 weighted imaging. Our findings indicate that the DWI may provide useful information in patients with suspected malignant hepatic lesions.

Keywords: Diffusion weighted imaging, hepatic focal lesions, malignant tumors

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INTRODUCTION:

Liver diseases have been known to affect mankind since the dawn of civilization and have steadily gained recognition as a major health problem principally because of their world-wide distribution. The symptoms of liver disease such as jaundice, fever, abdominal enlargement and encephalopathy are striking phenomenon that bring the patient to the physician. Clinical & biochemical examination provides information regarding liver size and functions but the assessment of the exact pathology is grossly inadequate.

Focal liver disease is a common diagnostic problem referred to radiologists for evaluation owing to its nonspecific clinical presentation and marked interobserver variation on clinical examination. Focal hepatic lesions include a large gamut of both benign and malignant lesions such as hepatic cysts, liver abscess, hemangioma, adenoma, focal nodular hyperplasia, hepatocellular carcinoma, hepatoblastoma, metastases etc.

Although dynamic contrast enhanced examinations have become a routine component of abdominal imaging, the high cost/benefit ratio and risk of contrast media side effects remain an issue. Moreover, sometimes it is not possible to distinguish between highly vascular metastases and hemangiomas, even using dynamic examinations.[1]

Diffusion weighted imaging (DWI) is another mechanism for developing image contrast and relies on changes in the diffusion properties of water molecules in tissues.[2] Diffusion is a physical property, which describes the microscopic random movement of (water) molecules driven by their internal thermal energy.

Stejskal and Tanner [3] were the first to describe an MR experiment that could be used to observe and measure water diffusion. They modified a standard T2-weighted imaging sequence by applying a symmetric pair of diffusion-sensitizing gradients on either side of the 180° refocusing pulse. Diffusion coefficients in DWI are reflected in the *apparent diffusion coefficient* (ADC, expressed in mm^2/s). [2]

Since the first brain diffusion imaging in 1986[4] and the widespread application for stroke detection in the early 1990s, diffusion-weighted (DW) MRI has evolved into a mature functional MR imaging technique for many brain imaging applications. With recent advances in technology, DW MR imaging is a potential tool for clinical use in the abdomen, particularly in the liver. DW MR imaging is an attractive technique for multiple reasons: it can potentially add useful qualitative and quantitative information to conventional imaging sequences; it is quick (performed within a breath hold) and can be easily incorporated to existing protocols; and it is a nonenhanced technique (performed without the use of gadolinium-based contrast media), thus easy to repeat, and useful in patients with severe renal dysfunction at risk for nephrogenic systemic fibrosis.[5]

The use of DWI in other parts of the body is relatively new, but very promising for the detection and differentiation of benign and malignant lesions, imaging for dissemination in oncological patients before treatment and for follow-up after treatment of liver tumors. Besides this, DWI is thought to be capable of predicting the response to therapy of malignant tumors.[2]

Diffusion images should be interpreted in conjunction with conventional sequences. In patients who cannot receive gadolinium-based contrast agents, DW MR imaging has the potential to be a reasonable alternative technique to contrast-enhanced imaging.[5]

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Hence the present study designed to evaluate the contribution of imaging science towards the evaluation and diagnosis of focal liver lesions.

Objectives:

• To detect and characterize focal liver lesions.
• To differentiate of benign from malignant liver lesions.
• To differentiate liver metastasis from primary liver lesions.

MATERIAL & METHODS:

Study Design: A prospective hospital based observational study.

Study area: Department of Radiodiagnosis, NRI Institute of Medical Sciences, Visakhapatnam.

Study Period: Jan 2021 – Feb. 2022.

Study population: Patients attending the department of Radio diagnosis, NRI Institute of Medical Sciences, Visakhapatnam.

Sample size: 30 patients with focal liver lesions.

Sampling method: Simple random method.

Inclusion criteria:

• All patients referred for MRI with clinically suspected focal liver lesions and patients with indeterminate liver lesions detected on USG or CT.
• Incidentally detected focal liver lesions.

Exclusion criteria:

• All patients having cardiac pacemakers, prosthetic heart valves, cochlear implants or any metallic implants.
• Patient having history of claustrophobia.

Ethical consideration: Institutional Ethical committee permission was taken prior to the commencement of the study.

Study tools and Data collection procedure:

All patients referred to the department of Radio diagnosis. Patients of all age groups referred to MRI, clinically suspected of focal liver lesions. Patients with indeterminate lesions detected on USG or CT.

Equipments:

The studies were conducted on the **Philips 1.5 Tesla Achieve machine.** A superconducting phased array XL-TORSO coil was used.

MRI PROTOCOL

T1WI, T2WI_TSE_FB, T2WI in axial and coronal planes.

In- and out-of-phase T1-weighted GRE in axial plane.

Post Contrast Dynamic Study (whenever Indicated): E-Thrive – 3D T1W TFE.

Respiratory-triggered (with a navigator-echo technique) Fat-suppressed (SPIR-selective presaturation using inversion recovery) single-shot echo-planar DW imaging was performed in the transverse plane with tridirectional diffusion gradients by using three *b* values (0, 500, and 1000 sec/mm^2) within the same acquisition, before contrast study.

The other parameters were as follows: repetition time msec/echo time msec, 2000–3000/67–82; matrix, 144 × 192; section thickness, 7 mm; intersection gap, 1.4 mm; field of view, 300–400 mm. Acquisition time was 6-8mins (dependent on respiratory rate).

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All ADCs were calculated on a workstation with standard software (Diffusion Calculation, GE Medical Systems). The signal intensities for ADC calculation were measured by using operator-defined region-of-interest (ROI). In large lesions the mean value of 3 different ROI measurements on the same slice was calculated. In lesions with necrotic or fibrous core, measurement of this area was avoided. ADC of normal liver parenchyma was calculated in area away from focal liver lesions.

STATISTICAL ANALYSIS:

Results expressed as mean, standard deviation, number and percentages. One-way ANOVA was used for multiple group comparison and student unpaired 't' test for 2 group comparison. Categorical data was analyzed by chi-square test. p-value of 0.05 or less was considered for statistically significant. SPSS version 16 software was used for data analysis.

OBSERVATIONS & RESULTS:

TABLE – 1: AGE AND SEX WISE DISTRIBUTION OF FOCAL LIVER LESIONS

Age group (years)	No. of patients	Percentage	Male	Female
<40	6	20.0	4	2
41-50	4	13.3	3	1
51-60	8	26.7	5	3
61-70	9	30.0	6	3
>70	3	10.0	1	2
Total	30	100	19	11

In the present study maximum percentage of patients were in age range of 61-70 years (30%). Mean age of patients in the study was 55.6 years.

TABLE – 2: SEX DISTRIBUTION

Sex	No. of patients	Percentage
Male	19	63.3
Female	11	36.7
Total	**30**	**100**

In the present study there was male preponderance (63.3%), when compared to females (36.7%). Male: Female – 1.7: 1.

TABLE – 3: DISTRIBUTION OF PATIENTS ACCORDING TO DIAGNOSIS

Diagnosis	No. of patients	Percentage
HCC	9	30
METASTASES	8	26.7
CholangioCa	2	6.7
Hemangioma	4	13.3

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Simple hepatic cyst	4	13.3
Hydatid cyst	3	10.0
Total	**30**	**100**

In the present study, most common lesion was HCC (30%), and mets were (26.7%). In the present study 76.6% of patients had multiple focal hepatic lesions. In present study most of patients (50%) had involvement of both lobe involvements.

TABLE – 4: AGE WISE DISTRIBUTION OF CASES

Diagnosis	<40	41-50	51-60	61-70	>70	Total
HCC	-	-	3	4	2	9
METS	1	1	3	2	1	8
Cholangio Ca	1	-	-	1	-	2
Hemangioma	1	-	-	3	-	4
Simple cyst	2	1	1	-	-	4
Hydatid cyst	1	2	-	-	-	3
Total	**6**	**4**	**7**	**10**	**3**	**30**
Percentage	**20**	**13.3**	**23.3**	**33.3**	**10**	**100**

In the present study out of 30, 19 (63.3%) were malignant and 11 (36.6%) were benign. 33% of patients were in the age group of 61-70 years. Most of the malignant lesions were seen in the age group of 51-70 years. Mean age of patients in the study was 55.6 years.

TABLE – 5: SEX WISE DISTRIBUTION OF DIAGNOSIS OF FOCAL LIVER LESIONS

Diagnosis	No. of cases	Male		Female	
		No	%	No.	%
HCC	9	8	88.9	1	11.1
METS	8	5	62.5	3	37.5
CholangioCa	2	1	50.0	1	50
Hemangioma	4	0	0	4	100
Simple hepatic cyst	4	3	7.5	1	25
Hydatid cyst	3	2	66.7	1	33.3
Total	**30**	**19**		**11**	

In the present study overall there were 19 males (63.3%) and 11 females (36.7%). Male: female = 1.7 :1. All lesions were common in males HCC (88.9%), metastasis (62.5%), simple cysts (75%), hydatid (66.7%) except hemangiomas which is common in females. Cholangio carcinoma had equal sex distribution.

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TABLE – 6: DISTRIBUTION OF PATIENTS ACCORDING TO SEVERITY OF DISEASE

Group	No.of patients	Percentage
Benign	11	36.66
Malignant	19	63.33

In the present study 19 (63.3%) were malignant and 11 (36.6%) were benign.

In the present study most of the HCC were between 2-5 cm, Metastasis, cholangio carcinoma and simple hepatic cyst were less than 2 cm in sizes. Most of the malignant lesions (n=26) 26 OUT OF 85, 30.6% were less than 2 cm in size. Most of hemangiomas and hydatid cysts were more than 2 cm in size.

TABLE – 7: DETECTION RATE OF FLLS IN 30 PATIENTS (85 lesions) WITH DWI AND T2 WEIGHTED IMAGING

Total no.of lesions	T2WI	DWI	Z value	P value
85	65	82	Z=3.99	P<0.001
100%	76.5	96.5	Highly significant	

DWI was associated with significantly higher detection rate of all FLLs when compared to T2WI. (p<0.001). DWI significantly improved the detection of FLLs when compared T2WI.

TABLE – 8: DETECTION RATE OF BENIGN AND MALIGNANT FLLS IN 30 PATIENTS (85 lesions) WITH DW AND T2 WEIGHTED IMAGING

Parameter	All lesions	Malignant	Benign
Total	85	63	22
T2WI	65 (76.51%)	44 (69.8%)	21 (95.5%)
DWI	82 (96.5%)	62 (98.4%)	20 (90.9%)
Z-value	3.99	4.77	0.61
P-value	<0.001 HS	<0.001 HS	0.54 NS

The number of malignant FLLs detected with DWI (62 out of 63 – 98.4%) was highly significant than that detected with T2 WI (P <0.001). There was no significant difference noted between DWI and T2 WI in detection of benign FLLs may be due to most of benign lesions were more than 2cm in size and benign lesions consisted only cystic lesions and hemangiomas, and no solid benign lesions (FNH and adenoma) were studied.

TABLE – 9: MEAN ADC OF BENIGN AND MALIGNANT LESIONS

Pathology	No. of lesions (n-82)*	ADC x 10^{-3} mm^2/s		Benign V/s malignant
		Mean	SD	
Benign	20	2.68	0.48	T=24.51
Malignant	62	0.92	0.17	P<0.001, HS

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* In 3 lesions no ADC detected.

t= unpaired t-test.

In the present study the mean ADC values of malignant lesions were significantly lower than those of benign lesions (0.92 x 10-3 mm2/s V/s 2.68 x 10-3 mm2/s) (p<0.001).

TABLE – 10: ADC COMPARISON BETWEEN HCC AND METS

Lesions	No. of lesions	ADC ($x10^{-3}$ mm^2/s)		HCC V/s Mets	
		Mean	SD	t*	P
HCC	23	1.03	0.10	7.74	<0.001 HS
Mets	35	0.81	0.11		

t= Unpaired t-test

In the present study the difference between mean ADC values of HCC and metastasis was significant. Even with significant difference, there was lot of overlap of ADC values among HCCs and metastasis.

DISCUSSION: A total of 30 patients (85 focal liver lesions) were studied. Diagnosis on MRI was made with background of clinical context. Final diagnoses were reached in consensus with biopsy/ FNAC wherever applicable or clinical, laboratory, other imaging modality findings and follow-up.

In our study, **age range** was of 17-85 years in which the maximum percentage of cases was seen in the age range of 61-70years (30%). Majority (44.4%) of the patients with HCC were in the age range of 61-70years. Metastases (37.5%) were commonly seen in age group of 51-60 years. Maximum cluster of cases with Hemangiomas (75%) were seen in age group of 61-70 years. Half of the patients diagnosed with cysts were seen in the age group of < 40 years. Two cases of intrahepatic cholangio carcinoma were in the age range of <40 and 61-70 years.

In our study, there was a male preponderance (63.3%) when compared to females who accounted for (36.7%) of cases. Male: Female sex ratio is **1.7: 1**. Regarding gender distribution among individual abnormality in our study: There was **male** preponderance in HCC (88.9%), and metastases (62.5%) simple cyst (75%), hydatid cyst (66.7%) when compared to females. Haemangiomas (100%) were seen in **females** only. Majority (90%) of patients had **multiple** focal liver lesions and 10% had **single** lesion. 15 (50%) of patients had bilateral lobe involvement. Out of 85 FLLs, 51(60%) were in right lobe and 34 (40%) were in left lobe.

Out of 30 patients 19 (63.3%) had **malignant** lesions, whereas 11 (36.6%) had **benign** lesions. There were total 85 lesions seen in 30 patients. Out of the total 85 focal liver lesions seen in 30 patients, 63 lesions (74.1%) accounted to malignancy and 22(25.9%) were of benign nature. Among the 30 patients, there were 9 with 23 HCCs, 2 with 4 cholangio carcinoma, 8 with 36 metastatic lesions, 11 with 22 benign lesions (6 hemangiomas in 4 patients, 9 cysts in 4 patients, 7 hydatid cysts in 3 patients).

Out of 85 FLLs (in 30 patients) 82 (96.5%) were detected by DWI and 65 (76.5%) by T2WI. DWI was associated with significantly higher detection rate of all FLLs when compared to T2WI (p <0.001). DWI MRI significantly improved the detection of FLLs when compared T2WI. These findings are comparable to **Parikh et al**[43] study wherein the number of malignant FLLs detected with DWI (62 out of 63 – 98.4%) was highly significant than those

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detected with T2 WI (p <0.001). However, there was no significant difference between the T2 weighted imaging and DWI for the detection of HCCs alone. This result was different from a previous study **[Parikh et al**[6]].

In our study, 20 of 23 (87%) HCCs were detected on T2 weighted imaging and 23 of 23 (100%) on DWI. There was no significant difference p=0.064(p>0.05). These findings where similar to **Palmucci s, et al**.[7] This may be explained by the different signal intensity observed in these lesions; In fact, in a recent study by Kim et al they were isointense or hyperintense to the liver. In a cirrhotic liver, HCCs may show the same signal intensity as the surrounding parenchyma, involved in a chronic fibrotic process, and as a consequence the detection and characterization of HCCs may be difficult. **Kim et al**[8].

This may also be due to their sizes; most of these lesions were in the group of more than 2cms. In our study DWI detection rate was significant in lesions less than 2cms.

Vandecaveye et al[9] concluded that DWI provided higher sensitivity and positive predictive value for the detection of HCC <20mm compared to conventional contrast enhanced MRI (sensitivity and specificity 91.2% and 82.9% vs 67.6% and 61.6%, positive predictive value 81.6% and 59.0%, respectively). DWI did not show significantly better results than conventional MRI in detecting HCC > 20 mm.

DW imaging was significantly better than T2-weighted imaging in terms of detection for both lobes (RL – 98% Vs 78%, LL – 94.1% Vs 73.5%). There was no significant difference for detection rate with DW imaging between right and left liver lobes (98% and 94.1%, respectively). These findings are comparable to **Parikh et al**.[6]

Coenegrachts et al[10] compared DW MR imaging (b values of 0, 20, 300, and 800 sec/mm^2) and single-shot T2-weighted fast SE in 24 patients with focal liver lesions. They found that the best image quality was achieved with single-shot T2-weighted fast SE imaging and the best lesion conspicuity was achieved with single-shot T2-weighted fast SE imaging for cysts and with DW MR imaging (b = 20 sec/mm2) for hemangiomas and metastases. DW MR imaging had the highest lesion-to-liver contrast-to-noise ratio for hemangiomas and metastases.

Bruegel et al[11] study group compared respiratory-triggered DW MR imaging to five different T2-weighted sequences (breath-hold fat-suppressed single shot T2-weighted fast SE, breath-hold fat-suppressed fast SE, respiratory-triggered fat-suppressed fast SE, breath-hold short inversion time inversion recovery, and respiratory-triggered short inversion time inversion recovery) for the diagnosis of hepatic metastases in 52 patients with 118 lesions at 1.5T. DW MR imaging demonstrated higher accuracy (0.91–0.92) compared with T2-weighted fast SE techniques (0.47–0.67). These differences were even more pronounced for small metastatic lesions (≤ 1 cm).

Zech et al[12] compared black-blood DW MR imaging (b = 50 sec/mm^2) with fat-suppressed T2-weighted imaging and observed significantly better image quality, fewer artifacts, and better sensitivity for lesion detection with DW MR imaging (83% versus 61%).

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TABLE – 11: Mean ADCs of Normal Liver and Focal Liver Lesions, ADC Cutoffs, and Sensitivity and Specificity for Diagnosing Malignant Lesions as Reported in Selected Studies compared with present study

Parmaeter	Namimoto et al[13]	Kim et al[14]	Taouli et al[15]	Bruegel et al[16]	Gourt-soyianni et al[17]	Parikh et al[6]	Present study
No.of patient s/ lesions	51/59	126/79	66/52	102/204	38/37	53/211	30/85
b values (sec/mm^2)	30,1200	≤846	≤500	50,300, 600	0,50,500, 1000	0,50,500	0, 500,1000
ADC values							
Normal liver	0.69	1.02	1.83	1.24	1.25-1.31	Not applicable	
Metastases	1.15	1.06-1.11	0.94	1.22	0.99	1.50	0.8
HCCs	0.99	0.97-1.28	1.33	1.05	1.38	1.31	1.03
Hemangiomas	1.95	2.04-2.10	2.95	1.92	1.90	2.04	2.04
Cysts	3.05	2.91-3.03	3.63	3.02	2.55	2.54	3.11
Adenomas – focal nodular hyperplasias	Not applicable	Not applicable	1.75	1.40	Not applicable	1.49	Not applicable
Benign lesions	1.95	2.49	2.45	2.2	2.55	2.19	2.68
Malignant lesions	1.04	1.01	1.08	1.63	1.04	1.39	0.92
ADC cutoff for diagnosis of malignant liver lesions‡	Not applicable	1.60	1.50	1.63	1.47	1.60	1.5
Sensitivity (%)	Not applicable	98	84	90	100	74	98
Specificity (%)	Not applicable	80	89	86	100	77	100

Malignant lesions such as HCC and liver metastases usually display low ADC values, except when treated and/or necrotic. Hepatic metastases that demonstrate substantial central necrosis can demonstrate high ADCs[18]. In comparison, liver metastases that arise from neuroendocrine tumors, which are characterized by small round cells at histologic examination, have low ADC values[19].

CONCLUSION:

From our study it can be concluded that the use of DWI was superior for the detection of malignant hepatic lesions than the use of T2 weighted imaging. Our findings indicate that the DWI may provide useful information in patients with suspected malignant hepatic lesions.

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