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Detection and Characterization of Focal Liver Lesions by Diffusion Weighted Magnetic Resonance Imaging

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ABSTRACT

Detection and characterization of focal liver lesions. The main sources of data for the study are patients from the following teaching Hospitals attached to Bapuji Education Association, J.J.M. Medical College, Davangere. Bapuji Hospital, Chigateri General Hospital. And S.S. Institute of Medical Sciences and Research Centre. 30 patients with focal liver lesions and additional 10 healthy volunteers with no focal liver lesion were studied to know to know normal ADC of liver. The incidence of focal liver lesions was highest in the age group of 61-70years (30%). Among the 30 included patients, there were 9 with 23 HCCs, 2 with 4 cholangiocelluar Carcinoma, 8 with 36 metastatic lesions, and 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 (30 patients) 82(96.5%) were detected by DWI and 65 (76.5%) by T2WI. DW imaging was associated with a significantly higher detection rate FLLs. ($P<0.001$). 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%) respectively. There was no significant difference for detection rate with DW imaging between right and left liver lobes (98% and 94.1%, respectively). No significant difference between DWI and T2WI for FLLS more than >2 cm. DW imaging was significantly better than T2-weighted imaging in terms of detection for both lobes ($p<0.001$). There was no significant difference for detection rate with DW imaging between right and left liver lobes (98% and 94.1%, respectively).

INTRODUCTION

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 abscesses, hemangioma, adenoma, focal nodular hyperplasia, hepatocellular carcinoma, hepatoblastoma, metastases etc.

Today, focal masses are diagnosed using ultrasonography (USG) and/or computed tomography (CT). Additionally, magnetic resonance imaging (MRI) is preferred when further characterization of these masses is needed. MRI has many advantages (e.g., high contrast resolution, the ability to obtain images in any plane, lack of ionizing radiation and the safety of using particulate contrast media rather than those containing iodine) that make it a favored modality. Lesion morphology, signal intensity and contrast enhancement pattern are taken into consideration when characterizing masses with MRI; however, even if the data are evaluated together, there can still be difficulties in the differentiation of benign and malignant lesions.

Diffusion weighted imaging (DWI) is another mechanism for developing image contrast and relies on changes in the diffusion properties of water molecules in tissues[1].

Diffusion is a physical property, which describes the microscopic random movement of (water) molecules driven by their internal thermal energy.

Restricted or impeded diffusion is seen in tissues with high cellularity, e.g. tumors, abscesses, fibrosis and cytotoxic edema. Relative free or unimpeded diffusion is encountered in tissues with low cellularity or tissues with disrupted cell membranes, for example in cysts and necrotic tissues. DWI relies on measuring diffusion of water molecules in the tissue by MRI. It uses a pulse sequence T2-weighted spin echo sequence) and 2 strong motion probing gradients on either side of the 180º refocusing pulse, known as the Stejskal-Tanner sequence.

MATERIALS AND METHODS

The main sources of data for the study are patients from the following teaching Hospitals attached to Bapuji Education Association, J.J.M. Medical College, Davangere.

- Bapuji Hospital.
- Chigateri General Hospital.
- S.S. Institute of Medical Sciences and Research Centre.

Sample Size : 30 patients with focal liver lesions and additional 10 healthy volunteers with no focal liver lesion were studied to know to know normal ADC of liver.

Diagnosis on MRI was made with background of clinical context. Final diagnoses was reached in consensus with biopsy/FNAC, wherever applicable or clinical, laboratory, other imaging modality findings and follow up.

Method of Collection of Data (Including Sampling Procedure if any):

- 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 in a period of 1 year 2 months from October 2011 to November 2012 were subjected for the study.

Inclusion Criteria :

The Study Includes:

- 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:

The Study will Exclude:

- All patients having cardiac pacemakers, prosthetic heart valves, cochlear implants or any metallic implants.
- Patient having history of claustrophobia.
- All patients who do not consent to be a part of the study.

Data 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. P-value of 0.05 or less was considered for statistically significant.

Equipments: The studies were conducted on the PHILIPS ACHIEVA 1.5 TESLA MRI. A 16 channel phased array XL-TORSO coil was used.

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/mm2) 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.

All ADCs were calculated on a workstation with standard software (Diffusion Calculation, Philips

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.

RESULTS AND DISCUSSIONS

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.

In the present study there was male preponderance (63.3%), when compared to females (36.7%). Male : Female-1.7 : 1. In the present study, most common lesion was HCC (30%), and mets were (26.7%).

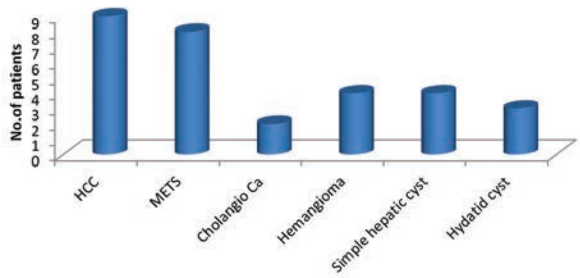

Fig.1: Distribution of patients according to diagnosis

Table 2 :Distribution of Patients According to Liver Lobes Involved

Lobe	No. of patients	Percentage
Right lobe (RL)	13	43
Left lobe (LL)	2	6.7
Both lobe (BL)	15	50

In present study most of patients (50%) had involvement of both lobe involvement.

In the present study 51 (60%). Out of 85 lesions were in the right lobe.

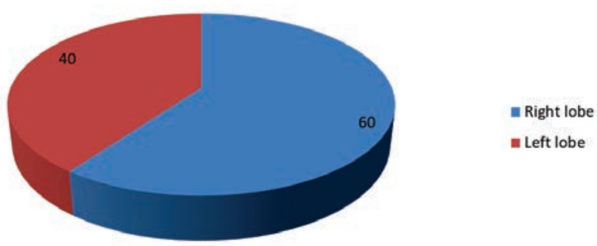

Fig.2: Distribution of lesions according to lobe involvement

Table 3 :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 4 :Sex Wise Distribution of Diagnosis of Focal Liver Lesions

Diagnosis	No. of cases	Male No	%	Female No.	%
HCC	9	8	88.9	1	11.1
METS	8	5	62.5	3	37.5
Cholangio Ca	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. 19(63.3%) were malignant and 11 (36.6%) were benign.

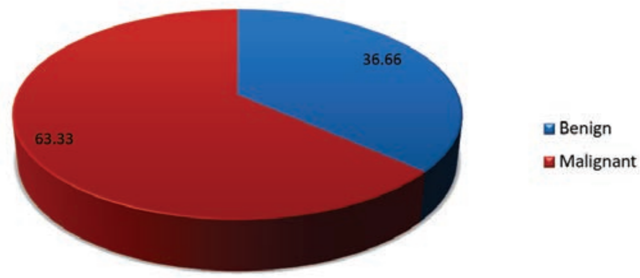

Fig.3: Severity of Disease

Out of 85 FLLs seen in 30 patients 22 (25.9%) was benign and 63 (74.1%) were malignant lesions.

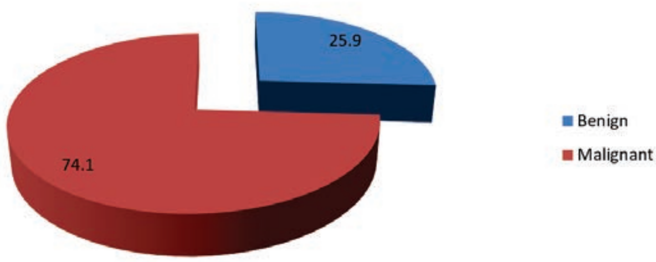

Fig.4: Distribution of the Total Flls According to Severity

Table 5 : Distribution of Each Flls According to Diagnosis

Diagnosis	No. of patients	No. of lesions	Percentage
HCC	9	23	27.1
Mets	8	36	42.4
Cholangio Ca	2	4	4.7
Hemangioma	4	6	7.1
Simple cyst	4	9	10.6
Hydatid cyst	3	7	8.2
Total	30	85	100

Most common lesion was metastasis (42.4%). In the present study, maximum 34 (40%) number of lesions were within <2 cm.

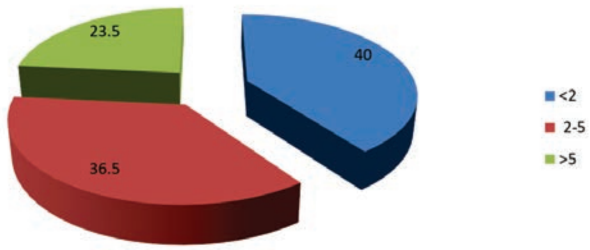

Fig.5: Distribution of Lesions According to Size

Table 6 : Stratification of Lesions by Size (n=85)

Diagnosis	<2cm	2-5 cm	>5 cm	Total
HCC	6	9	8	23
Mets	18	14	4	36
Cholangio Ca	2	1	1	4
Hemangioma	2	1	3	6
Simple hepatic cyst	6	3	0	9
Hydatid cyst	0	3	4	7
Total	34	31	20	85

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 <2 cm in size.

Most of hemangiomas and hydatid cysts were more than 2 cm in size.

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 7 : Determination of 85 Flls In 30 Patients with DWI and T2WI Stratified by Location (RL/LL)

Parameter	RL (n=51)		LL (n-34)	
	No	%	No	%
DWI	50	98	32	94.1
T2WI	40	78	25	73.5

DWI was significantly better than T2W imaging in terms of detection for both lobes (RL-98% Vs 78%, LL -94.1% Vs 73.5% respectively).

There was no significant difference for detection rate with DWI between right and left lobes (98% Vs 94.1%)

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

Among the 30 included 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 maximum number 34(40%) of FLLs were within <2 cm and 31(36.5%) were b/w 2-5cm and 20 lesions were >5cm. Most of malignant lesions 26 out 63 (41%) were in<2cm range, Most of HCCs 9 of 23 lesions were in 2-5cm range and only 6 of 23 were in less than 2cm range.

Most of metastasis (18 of 36), cholongio carcinoma (2 of 4) and simple hepatic cysts (6 of 9) lesions were in less than 2cm range.

Out of 85 FLLs (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[2] 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).

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[2]].

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>.05). These findings where similar to Palmucci[3].

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[4].

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[5] concluded that DWI provided higher sensitivity and positive predictive value for the detection of HCC <20 mm 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.

There was no difference determined between the use of T2 weighted imaging and DWI for the detection of benign hepatic lesions in our study. This result was different from a previous study [Parikh[2]].

In our study, 21 of 22 (95.5%) benign hepatic lesions were detected on T2 weighted images and 20 of 22(90.9%) on DWI. These findings were comparable to Yang[6].

However, in a study by Parikh et al2, 83.3% of benign hepatic lesions were detected on T2 weighted images and 90% of benign hepatic lesions were detected on DWI.

We think that this difference is due to a different lesion distribution between the two studies. All of the benign lesions in our study were cystic lesions including haemangiomas and cysts. Conversely, benign hepatic lesions in the study by Parikh[2] were composed of both solid and cystic lesions including haemangiomas, cysts, adenomas, liver abscesses, focal nodular hyperplasia and intrahepatic haematomas. Haemangiomas and cysts are usually detected on T2 weighted images. However, a small benign solid tumour might not be detected on T2 weighted images because of less conspicuity of the solid lesions by the magnetisation transfer (MT) effect[7].

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[2].

Parikh[2] study showed that DW MR imaging significantly improved detection of small malignant lesions less than 2 cm when compared with breath old T2-weighted imaging (78.5% vs.45.8%, P<.001).

Several publications have reported the use of DW MR imaging for liver lesion detection[2-8-9] FCW of these studies have compared DW MR imaging and T2-weighted imaging in terms of lesion detection, generally showing improved detection with DW MR imaging[8-10]terms of image quality, findings showed comparable image quality with that of DW MR imaging by using low b values[11] Black-blood diffusion images (using low b values), in which background signal of vessels in the liver parenchyma is suppressed, allow for lesion detection[10-11] while images with higher b values give diffusion information that enable lesion characterization[2-12-13]The improved lesion detection with DW MR imaging compared with T2-weighted imaging is explained by the improved image contrast with use of low b values and lack of blurring with single-shot SE echo-planar imaging, compared with T2-weighted fast SE or single-shot fast SE sequences[11] Coenegrachts[8]compared DW MR imaging (b values of 0, 20, 300, and 800 sec/mm2) 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.

In another study, Bruegel[14] aredrespiratory-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 al9 compared black-blood DW MR imaging (b =50 sec/mm2) 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%).

T2 Weighted Imaging: On T2WI-30 (35.3%) were hyper, 25 (29.4%) were heterogensity hyper, all hydatid cyst had hyper with low intensity rim with multiple daughter cysts and 20 FLLs were not detected. None of lesions were hypo on T2WI.

CONCLUSION

No significant difference between DWI and T2WI for FLLS more than >2 cm.

DW imaging was significantly better than T2-weighted imaging in terms of detection for both lobes (p<0.001). There was no significant difference for detection rate with DW imaging between right and left liver lobes (98% and 94.1%, respectively). On low b-value diffusion- weighted MR images, all masses were observed as hyperintense, whereas on high b-value images signals of cysts disappeared and signals of hemangiomas obviously decreased. In contrast, since there is a limitation of diffusion in solid tumors, they were also observed as hyperintense on high b-value diffusion weighted images.

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