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ROLE OF DIFFUSION WEIGHTED MAGNETIC RESONANCE IMAGING IN THE EVALUATION OF FOCAL LIVER LESIONS

Radiology

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ABSTRACT

Focal hepatic lesions include a large number of benign and malignant pathologies. These are common diagnostic problems referred to radiologists owing to their non-specific clinical presentation. Accurate detection of these plays a vital role in their markedly varying management. Diffusion weighted magnetic resonance imaging and apparent diffusion coefficient mapping are non invasive, non contrast imaging techniques which can aid in detection and characterization of various pathological conditions. This study is to evaluate its contribution in detection and evaluation of focal hepatic lesions.

KEYWORDS

Focal Liver lesions, Diffusion Weighted Imaging, Apparent Diffusion Coefficient, Magnetic Resonance Imaging.

INTRODUCTION:

Liver diseases have been steadily gaining recognition becoming a major health problem necessarily due to their world-wide distribution. Clinical examination and biochemical parameters provide information regarding the liver size and function but the exact assessment of the pathology is still grossly inadequate. Due to their varied and vague clinical presentation and significant inter observer variation on examination, they pose various diagnostic difficulties.

Focal hepatic lesions include a large variety of benign and malignant lesions. With the development of modern treatment techniques, strategies and local therapies, the detection of these lesions, determination of liver lesion count and characterization of the nature of these lesions are extremely important for specific management of the different pathological processes.

Today, focal liver lesions are initially diagnosed using ultrasonography (USG) and/or computed tomography (CT). In addition to this, magnetic resonance imaging (MRI) is also preferred when further characterization is required. MRI has a number of advantages making it a more favored modality. Signal intensity, lesion morphology, location, mass effect and invasion are taken into consideration while characterizing these lesions. However, there can still be difficulties in differentiating benign and malignant lesions. With the introduction of MRI contrast agents, Contrast enhanced MRI has the potential to become the leading imaging modality in evaluation of liver lesions.

Diffusion weighted magnetic resonance imaging (DWI) is another mechanism for developing image contrast, relying on the changes in the diffusion properties of water molecules in different tissues[10]. Diffusion images are generally interpreted in conjunction with conventional sequences. In patients with relative and absolute contraindication to receive gadolinium-based contrast agents, DW MR imaging has the potential to be a fairly reasonable alternative imaging technique to contrast-enhanced imaging. [4]

In this study, we evaluate the contribution of diffusion weighted magnetic resonance imaging and quantitative analysis by apparent diffusion coefficient mapping in the evaluation, detection and characterization of focal liver lesions.

Aims & Objectives:

1. To determine the role and significance of diffusion weighted imaging and apparent diffusion coefficient mapping for characterization of liver lesions.
2. To determine the mean apparent diffusion coefficient (ADC) value of various focal liver lesions which can aid in obtaining a reasonable cut off value to differentiate benign from malignant lesions.

METHODS AND MATERIALS:

A total of 30 patients of all age groups with clinical/ biochemical/ preliminary imaging features of hepatic lesions referred to the department of Radio diagnosis of Saveetha Medical College & Hospital (for a period of 2 years) were subjected to diffusion weighted magnetic resonance imaging and apparent diffusion coefficient mapping on Philips Achieva 1.5 Tesla MRI machine. MRI sequences included axial DWI (b values 0 and 800) and axial ADC mapped images, in addition to the routine non contrast MR sequences for hepatic imaging. Circular Regions Of interest (ROIs) of 90-110mm2 were drawn on the ADC images (from the area of least signal intensity of the pathological lesion or from the area of least signal intensity of the wall in suspected abscesses or metastases).

Final diagnosis was reached in consensus with histopathological examination wherever applicable. In the rest of the cases closest diagnosis was obtained on the basis of laboratory and other preliminary imaging modality findings (USG/ CT/ Conventional MRI sequences).

Statistical analysis:

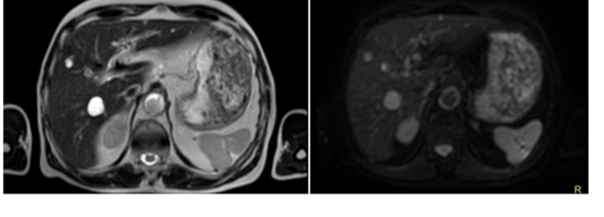
The ADC of focal hepatic lesions was considered as primary outcome variable.

Nature of the lesion on histopathological examination wherever applicable/ imaging diagnosis were considered as explanatory variable.

The sensitivity, receiver operating characteristic curve, specificity, positive predictive value (PPV) and negative predictive value (NPV) were calculated.

Demo graphic parameters like age, gender, socio economic status etc. were the other explanatory variables.

Descriptive analysis was carried out by mean and standard deviation for quantitative variables, frequency and proportion for categorical variables. Data was also represented using appropriate diagrams like bar diagram, cluster bar and pie diagram. The association between explanatory variables and categorical outcomes was assessed by cross tabulation and comparison of percentages. Chi square test was used to test statistical significance.



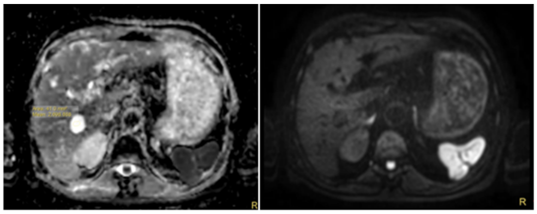


Figure 1: A case of simple hepatic cysts in a 70 year old male. (Clockwise direction) – T2W image showing multiple well defined hyperintense lesions in both lobes of liver which show no significant diffusion restriction on increasing b values (0,800) with a mean ADC value of 2.6 x 10^{-3} mm^2/s.

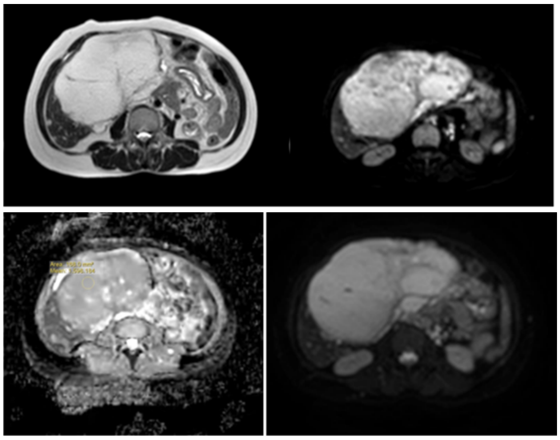


Figure 2: A case of biopsy proven giant hemangioma in a 50 year old female. (Clockwise direction) – T2W image showing a large well defined hyperintense lesion involving both lobes of liver with a central hypointense scar which shows no significant diffusion restriction on increasing b values (0,800) with a mean ADC value of 1.6 x 10^{-3} mm^2/s.

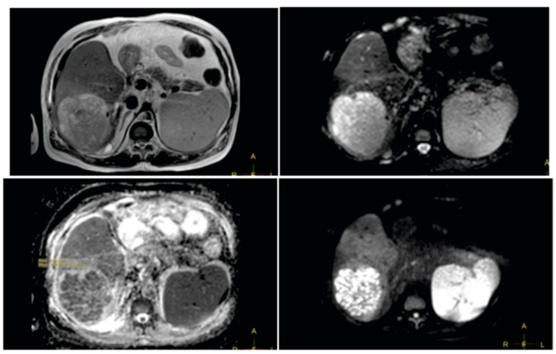


Figure 3: A case of hepatic abscess in a 34 year old male. (Clockwise direction) – T2W image showing a hyperintense well defined lesion in the right lobe of liver which shows restricted diffusion on increasing b values (0,800) with a mean ADC value of 1.5 x 10^{-3} mm^2 (taken along the wall of the lesion).

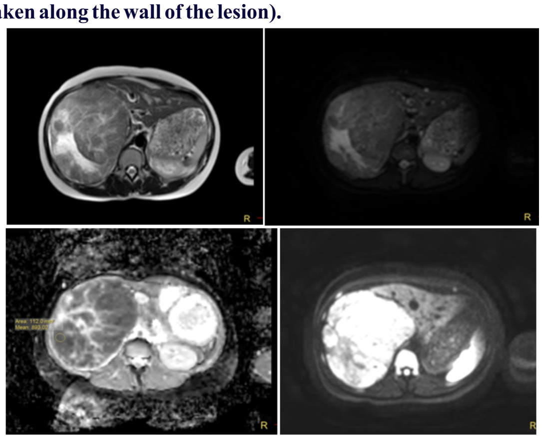


Figure 4: Biopsy proven case of hepatocellular carcinoma in a 30 year old female. (Clockwise direction) – T2W image showing a heterogeneously iso to mildly increased intensity well defined lesion occupying the right lobe of liver with a central hyperintense scar which shows restricted diffusion on increasing b values (0,800) with a mean ADC value of 0.8 x 10^{-3} mm^2/s.

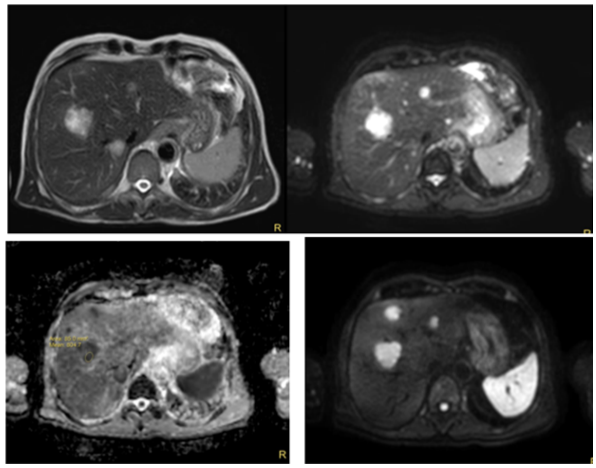


Figure 5: Biopsy proven case of hepatic metastases in a 68 year old male. (Clockwise direction) – T2W image showing multiple predominantly hyperintense well defined lesions in both lobes of liver which show restricted diffusion on increasing b values (0,800) with a mean ADC value of 0.8 x 10^{-3} mm^2/s.

RESULTS:

1. The maximum number of patients with focal liver lesions in our study were in the age group of 41 to 60 years.
2. Males had a significantly higher incidence of focal liver lesions.
3. Lesions occurred more commonly in the right lobe when compared to the left.
4. Of the 30 lesions, 16 were malignant and 14 were benign.
5. Cysts and Hemangiomas turned out to be the commonest benign hepatic lesions whereas metastases were the commonest malignant hepatic lesions.
6. Nine different pathological lesions, both benign and malignant were studied with the mean ADC values for each as listed below.

Table 1: Distribution of each pathological lesion with its mean ADC value

LESIONS	Mean value of the quantitative ADC analysis (x 10-3mm2/s)
Cyst	2.6
Hemangioma	1.6
Metastases	0.8
Hepatocellular Carcinoma	0.9
Abscess	1.5
Hydatid Cyst	2.7
Cholangiocarcinoma	1
Hepatocellular Adenoma	1.29
Focal Nodular Hyperplasia	1.4

7. There was significant difference between the mean ADC value of all benign and malignant lesions. With this, we arrived at a cut-off value of 1.3 x 10^{-3} mm^2/s, above which there was more probability of lesions being benign and below which malignancy was more likely.

Table 2: Comparison of the nature of lesions concluded on ADC analysis with the nature as concluded on HPE

	Nature on HPE	
Nature on ADC analysis (keeping the cutoff value at 1.3 x 10^{-3} mm^2)	**Malignant (16)**	**Benign (14)**
Benign (13)	0	13
Malignant (17)	16	1

1. On ADC analysis, one focal hepatic lesion which was below the cut off value turned out to be benign (hepatic adenoma) on HPE.
2. However the ADC values of all malignant lesions were below the cut off value.
3. Another lesion which was concluded to be benign on clinical suspicion/ preliminary imaging (prior to DWI and ADC analysis),

showed a value of less than the cut off, concluding it to be malignant which was confirmed on HPE (Hepatocellular Carcinoma). This showed the increased sensitivity of DWI and quantitative ADC analysis in detection of the malignant nature of the lesions over conventional MR sequences/ other basic imaging modalities.

Thus, all the malignant lesions had an ADC mean of less than 1.3 (as per the estimated cut off of this study), considering it to be highly significant (**P value <0.001**). From the above data we can estimate the following statistical parameters of quantitative ADC analysis in the characterization of focal hepatic lesions as follows:

Sensitivity = 100%, Specificity = 93%
PPV= 94%, NPV = 100%

DISCUSSION:

Diffusion-weighted imaging (DWI) detects the random, thermally driven, motion of water protons (Brownian motion) in biological tissues, deriving image contrast based on the difference in water diffusivity within tissues. Water protons exist in the intra- and extracellular spaces in the body. Free diffusion is modified by the bulk capillary flow, their interaction with cell membranes & macromolecules thereby providing an insight into the cellular architecture at the micrometer scale. In highly cellular tissues (e.g. tumors), the extracellular space tortuosity and cell membrane density restrict the apparent diffusion of water. In contrast to this, cystic and necrotic tissues have lesser barriers to water diffusion, thus the apparent diffusion is relatively free.

Lower ADC values indicate restricted diffusion (highly cellular tissues) whereas higher ADC values signify more free water diffusion (tissues with low cellularity). Thus, ADC values of benign cystic lesions were much higher than the ADC values of malignant lesions. There was no significant difference between the ADC values of HCC, metastases and Cholangiocarcinoma.

Various studies have reported the significance of DWI in differentiating benign from malignant lesions based on their ADC values. All have reported lower ADC values for benign lesions and higher ADC values for malignant lesions. In our study we arrived at a cut-off value of 1.3 x 10-3mm2/s, above which there was more probability of lesions being benign and below which malignancy was more likely. The comparative results based on other studies can be tabulated as follows.

Table 3: Mean ADC values (x $10^{-3}mm^2/s$) of the focal hepatic lesions, benign and malignant lesions with a cut off value, its sensitivity and specificity as determined by other studies in comparison to our study:

	Gourtsoyianni et al. [3]	Kandpal et al. [5]	Holzapfel et al. [6]	Bruegel et al. [2]	Joao P et al. [1]	Our study
HCC	1.38	1.27	1.1	1.05	1.1	0.9
Metastases	0.9	1.1	1.0	1.2	1.1	0.8
Cyst	3.5	2.9	2.6	3.0	2.7	2.72
Hemangioma	1.9	2.3	1.7	1.9	1.8	1.6
FNH	-	2.1	-	1.4	1.6	1.4
Adenoma	-	-	1.4	-	1.3	1.29
Benign Lesions	2.5	-	2.3	-	2.0	1.8
Malignant Lesions	1.04	-	1.0	-	1.1	0.8
Cut off	1.4	1.4	1.5	1.4	1,4	1.3
Sensitivity (%)	100	91	100	90	90	100
Specificity (%)	100	90	100	86	91	92

CONCLUSION:

- There is a significant role for DWI and ADC mapping in the characterization of liver lesions.
- Mean apparent diffusion coefficient (ADC) values of various focal liver lesions have been determined without major overlap and thereby obtained a reasonable cut off value to differentiate benign and malignant lesions.
- DWI & ADC mapping could be useful tools complementing conventional MR imaging and other imaging modalities in the characterization of focal liver lesions.

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