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Role of Diffusion Weighted Magnetic Resonance Imaging in Focal Liver Lesions

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Abstract: Aims*:*
1. *Detection and characterization of focal liver lesions.*
2. *Differentiation of benign from malignant liver lesions.*
3. *Differentiation of liver metastasis from primary liver lesions.*
4. *To compare respiratory triggered diffusion weighted single shot echo planar imaging (RT DW-SS-EPI) and T2 weighted turbo spin echo imaging (T2W TSE).*
5. *To determine apparent diffusion coefficients (ADCs) of focal liver lesions and normal liver parenchyma.*

Material And Methods: *30 patients were subjected to MRI scan using Philips Achieva 1.5 Tesla MRI.*

Results: *In the present study maximum percentage of patients were in age range of 61-70 years (30%). There was male preponderance (63.3%), when compared to females (36.7%). Most common lesion was HCC (30%), and mets were (26.7%). Out of 30, 19 (63.3%) were malignant and 11 (36.6%) were benign.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).*

Conclusion: *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. However, in our populations, no significant difference was observed between DWI and T2 weighted imaging for the detection of bening hepatic lesions, which included only cysts and hemangiomas and characterization of hepatic lesions.*

I. 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. Clinical & biochemical examination provide 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 forevaluation owing to its nonspecific clinical presentation and marked interobservervariation on clinical examination. Focal hepatic lesions include a large gamut of both benign and malignant lesions .

Modern operative techniques and local therapies such as radiofrequency (RF) ablation are effective methods to treat liver metastases or primary hepatic malignancies. Therefore, the determination of liver lesion count, and the nature of the lesion are important.

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 making it a favored modality. Lesion morphology, signal intensity, and contrast enhancement pattern are taken into consideration when characterizing masses with MRI. There can still be difficulties in the differentiation of benign and malignant lesions.

With introduction of MRI contrast agents, MRI with contrast material enhancementhas potential to become the leading imaging modality in evaluation of liver. MRI is currently considered to be the most accurate noninvasive method in the evaluation of liver lesions .The utilization of tissue specific contrast agents such as SPIO or MnDPDP, and the possibility to employ MR techniques that alter tissue contrast such as MT and the multiple slices SL render MRI an attractive tool for liverimaging.

It is not possible to distinguish between highly vascular metastases and hemangiomas, even using dynamic examinations.1Diffusion 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 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

This study is designed to evaluate the contribution of imaging science towards the evaluation and diagnosis of focal liver lesions. Objective is to detect and characterize focal liver lesions, differentiate benign from malignant liver lesions and to differentiate liver metastasis from primary liver lesions.

II. Methodology

Source of data: Patients admitted to three tertiary care hospitals.

Study area: Two private teaching hospitals in Davanagere district i.eBapuji Hospital and S.S. Institute of Medical Sciences and also Davanagere district government hospital

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

Sample selection: All patients referred to the department of Radio diagnosis Patients of all age groups referred to MRI clinically suspected of focal liver lesions were considered for study. Patients with indeterminate lesions detected on USG or CT were also included.

Study period: October 2012 to November 2012 [1 year ,2 months]

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. All patients who do not consent to be a part of the study.

Data Analysis:
Descriptive statistics was used to interpret data. 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.

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

MRI protocol
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.

III. Results

Table – 1 :Age 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 wise distribution of focal liver lesions

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
METS	8	26.7
CholangioCa	2	6.7
Hemangioma	4	13.3
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%).

Table – 4 :Distribution of patient according to multiplicity of hepatic mass

Type of lesion	No.of patients	Percentage
Single	7	23.3
Multiple	23	76.6
Total	**30**	**100**

In the present study 76.6% of patients had multiple focal hepatic lesions.

Table – 5 : 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.

Table – 6 : Distribution of cases according to age and diagnosis

Diagnosis	<40	41-50	51-60	61-70	>70	Total
HCC	-	-	3	4	2	9
METS	1	1	3	2	1	8
CholangioCa	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 – 7 :Distribution of cases according to sex and diagnosis

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

Table – 8 :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.

Table – 9: Distribution of the total flls according to severity (n=85)

Group	No.of lesions	Percentage
Benign	22	25.9
Malignant	63	74.1
Total	**65**	**100**

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

Table – 10 : 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
CholangioCa	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%).

Table – 11 : Distribution of lesions by size and diagnosis (n=85)

Diagnosis	<2cm	2-5 cm	>5 cm	Total
HCC	6	9	8	23
Mets	18	14	4	36
CholangioCa	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 HCCwere 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 – 12 : 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 and hemangioma lesion, and no solid benign lesions (FNH and adenoma) were studied.

Table – 13 :lesions detection rate by according to size

Parameter	<2 (n=34)	2.0 – 5 (n=31)	≥ 5.0 (n=20)
DWI	31 (91.2%)	31 (100%)	20 (100%)
T2 WI	14 (41.2%)	31 (100%)	20 (100%)
Z	5.13	0.0	0.0
P	<0.001 HS	1.00 NS	1.00 NS

The detection rate was stratified according to the lesion size. There was significant difference only for detection of FLLs with the diameter of less than 2 cm (p<0.001).

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

Malignant lesions:

All HCCs and cholangio ca. detected on DWI were hyperintense on DWI b=0, b=500, b=1000 and hypointense on ADC map.

Metastasis : All lesions were hyper on b=0. Most of the lesions were hyper (55.5%) and 41.6% were P.hyper on b=500 and b=1000. All theseP.hyper lesions were more than 1 cm.

Malignant lesions retained high signal intensity on high b values.

Benign lesions:

Hemangioma – DWI – on b=0 hyper and on high b=values (b=500 and b=1000) then was obvious signal intensity reduction. On ADC hemangiomas were Iso-hyper, or heterogeneously hyper. This may be due to T2 shine through effect.

Hydatidcysts - On low b-values (b=0) all lesions were hyper there was gradual decrease in signal on high b-values (b=500 moderate hyper and b=1000 – Iso). On ADC map all lesions were hyper.

Simple cysts:All detected lesions on DWI hyper on low b-values (b=0) and Iso – Hypo on high b-values (b=500, b=1000) on ADC all lesions were hyper intense.

IV. Discussion

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

Majority of cases was seen in the age range of 61-70years (30%).Majority (44.4%) of the patients with HCC (Fig.1) were in the age range of 61-70years.Metastases (37.5%) (Fig.3) were commonly seen in age group of 51-60years.

Majority (75%)of the patients with Hemangiomaswere seen in age group of 61-70years.Majority (50%)of the patients with cysts were seen age group of < 40 years.Two cases of intrahepatic Cholangiocarcinoma (Fig.2) were in the age range of<40and 61-70years.

In our study, there was a male preponderance (63.3%) when compared to females whoaccounted for (36.7%) of cases.Sex ratio was Male: Female – 1.7: 1.

Regarding gender distribution, there was male preponderance in HCC (88.9%), andmetastases (62.5%) simple cyst (75%) (Fig.6), hydatidcyst (66.7%) (Fig.4) when compared to females. Haemangiomas (100%) (Fig.5) were seen in females only.

Majority(90%) of patients had multiple focal liver lesions and 10% had single lesion and majority 15 (50%) of patients had both lobe involvement.

Out of 30 patients 19(63.3%) had malignant lesions whereas 11 (36.6%) had benign lesions. total 85 lesions seen in 30 patients. Benign hepatocellular mass lesions were first evaluated by Taouliet al[52] and their ADC values were found to be lower than cysts and hemangiomas, and higher than malignant masses.

Out of the total 85 focal liver lesions seen in 30 patients there were 63(74.1%) were malignant and 22(25.9%) were benign lesions.

Among the 30 included patients, there were 9 with 23 HCCs, 2 with 4 cholangiocarcinoma,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).

Regarding size distribution among individual FLLs in our study:

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 more than 5cm. Most of malignant lesions 26 out 63 (41%) were in less than 2cm range,Most of HCCs 9 of 23 lesionswere in 2-5cm range and only 6 of 23 were in less than 2cm range.

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

Limitations

Patient population was small and all of the benign lesions were cystic lesions, including haemangiomas and cysts. Solid benign lesions such as adenomas and focal nodular hyperplasia were not encountered.

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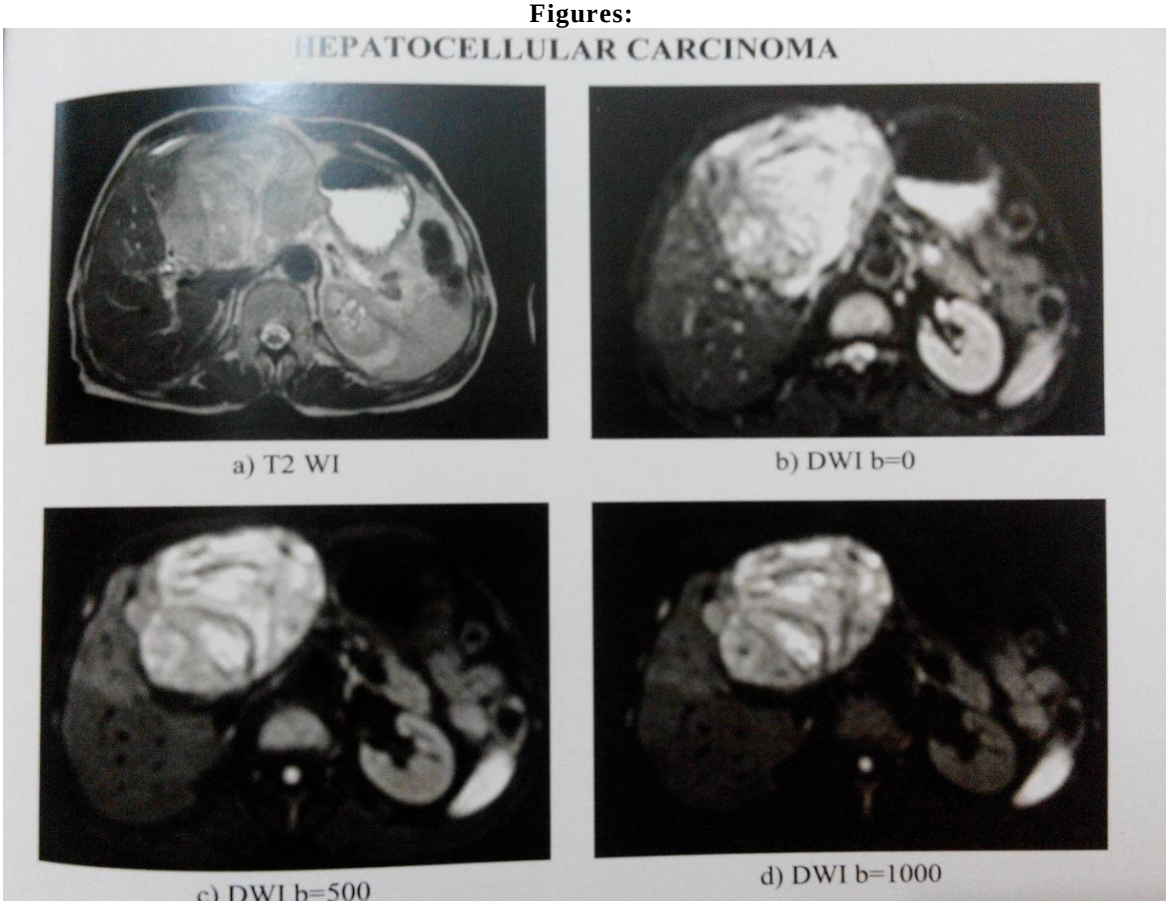
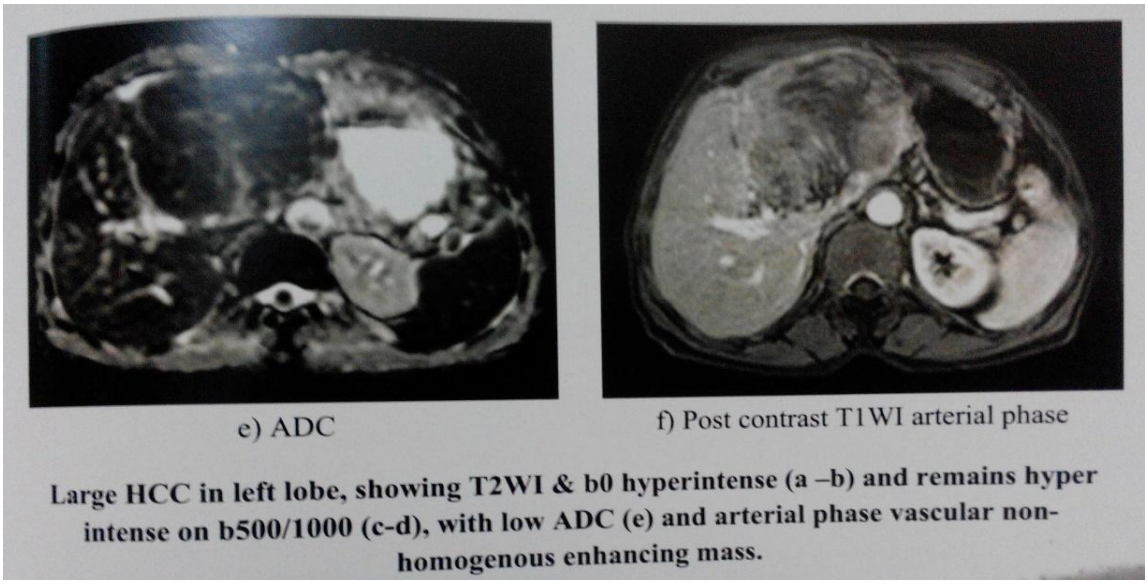
Figures:



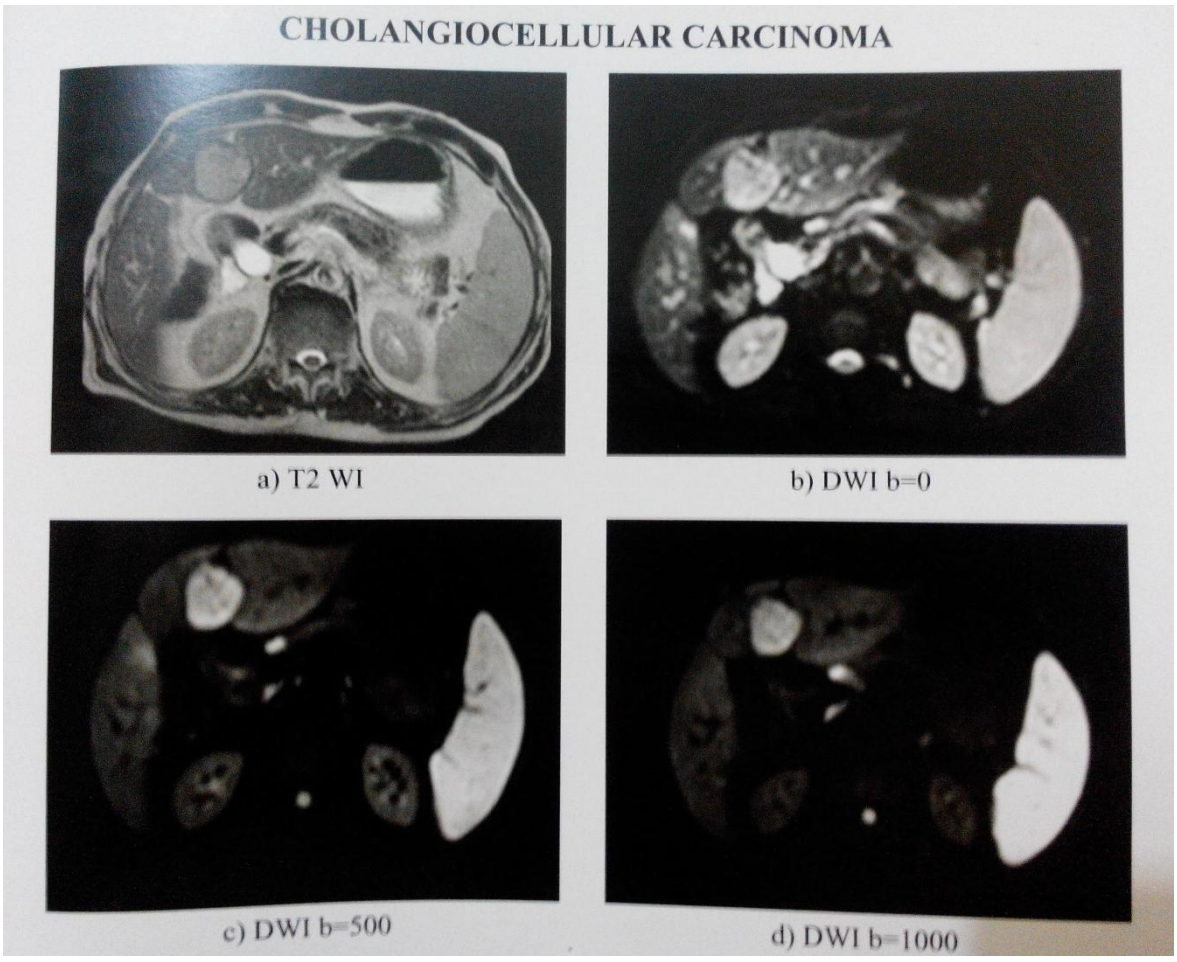


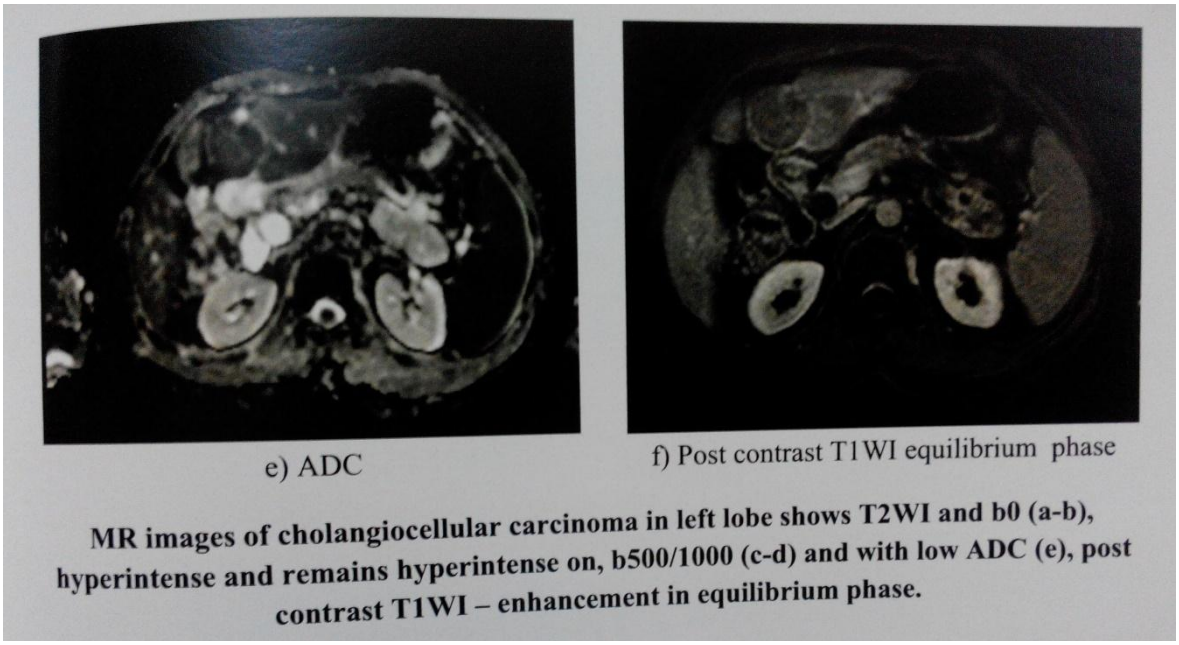
e) ADC

f) Post contrast T1WI arterial phase

Large HCC in left lobe, showing T2WI & b0 hyperintense (a –b) and remains hyper intense on b500/1000 (c-d), with low ADC (e) and arterial phase vascular non-homogenous enhancing mass.

Fig.1



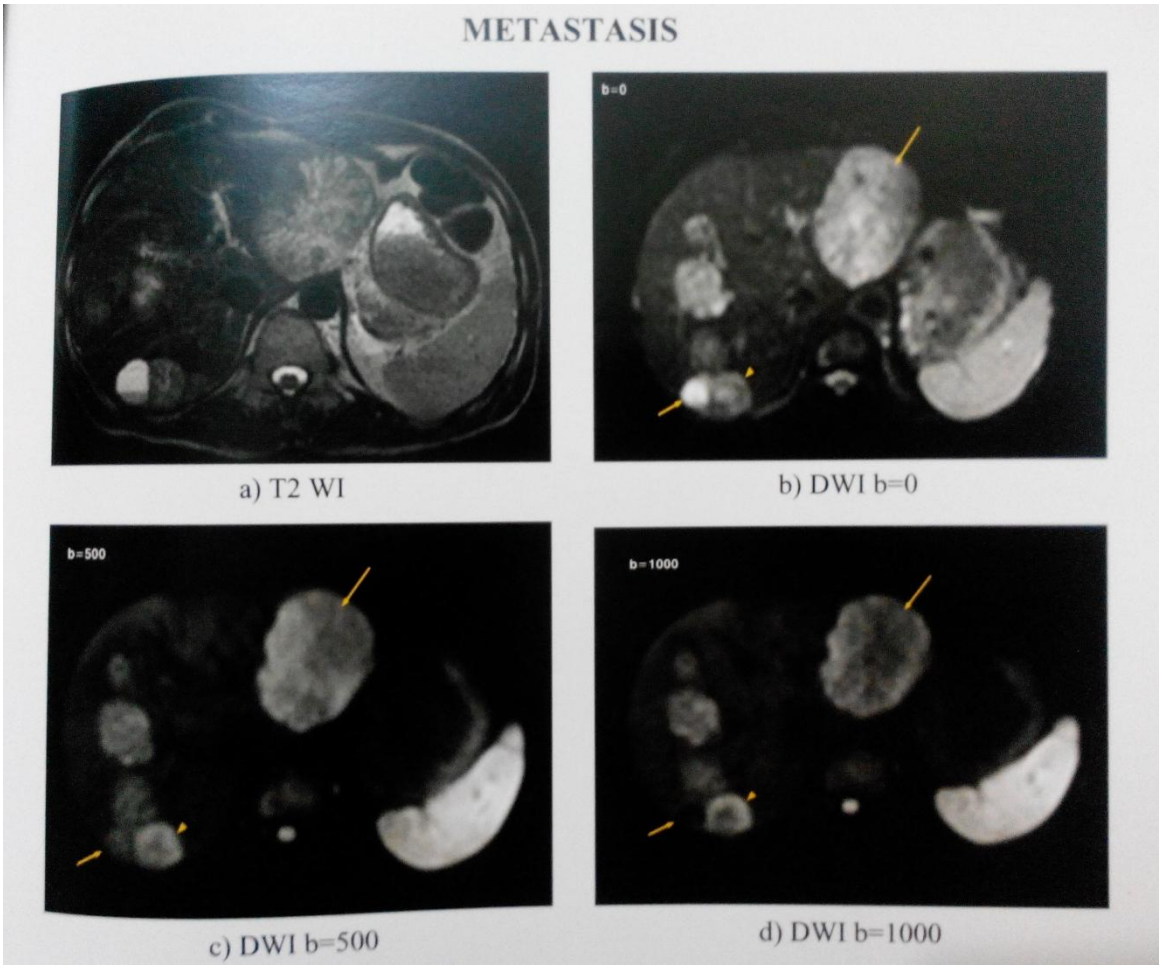


e) ADC

f) Post contrast T1WI equilibrium phase

MR images of cholangiocellular carcinoma in left lobe shows T2WI and b0 (a-b), hyperintense and remains hyperintense on, b500/1000 (c-d) and with low ADC (e), post contrast T1WI – enhancement in equilibrium phase.

Fig.2

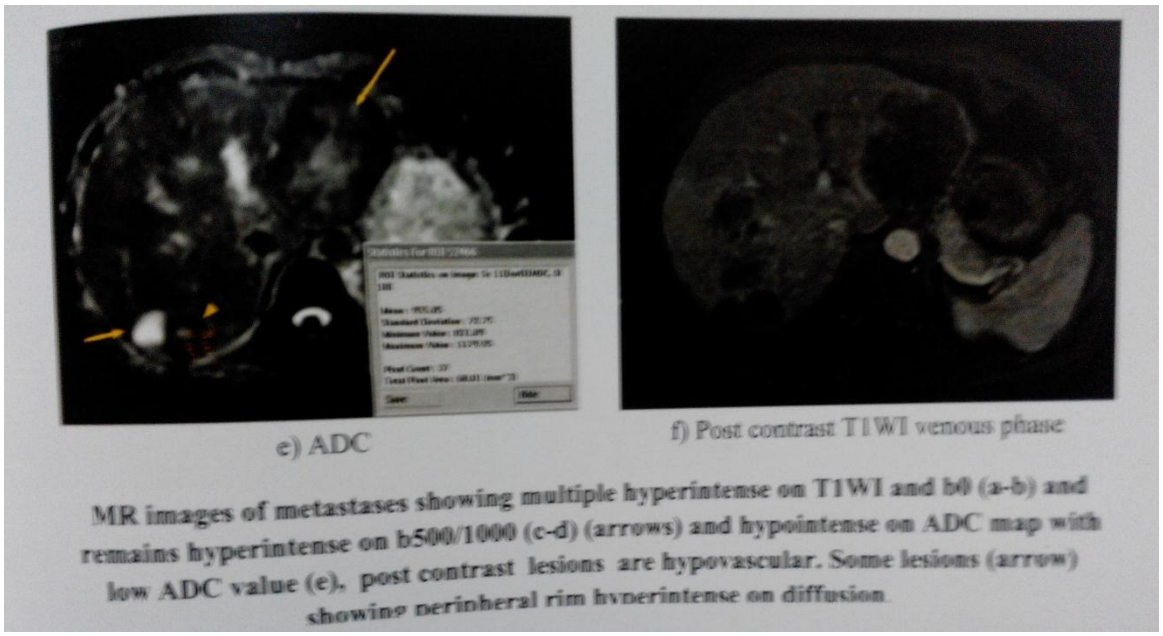


a) T2 WI

b) DWI b=0

c) DWI b=500

d) DWI b=1000

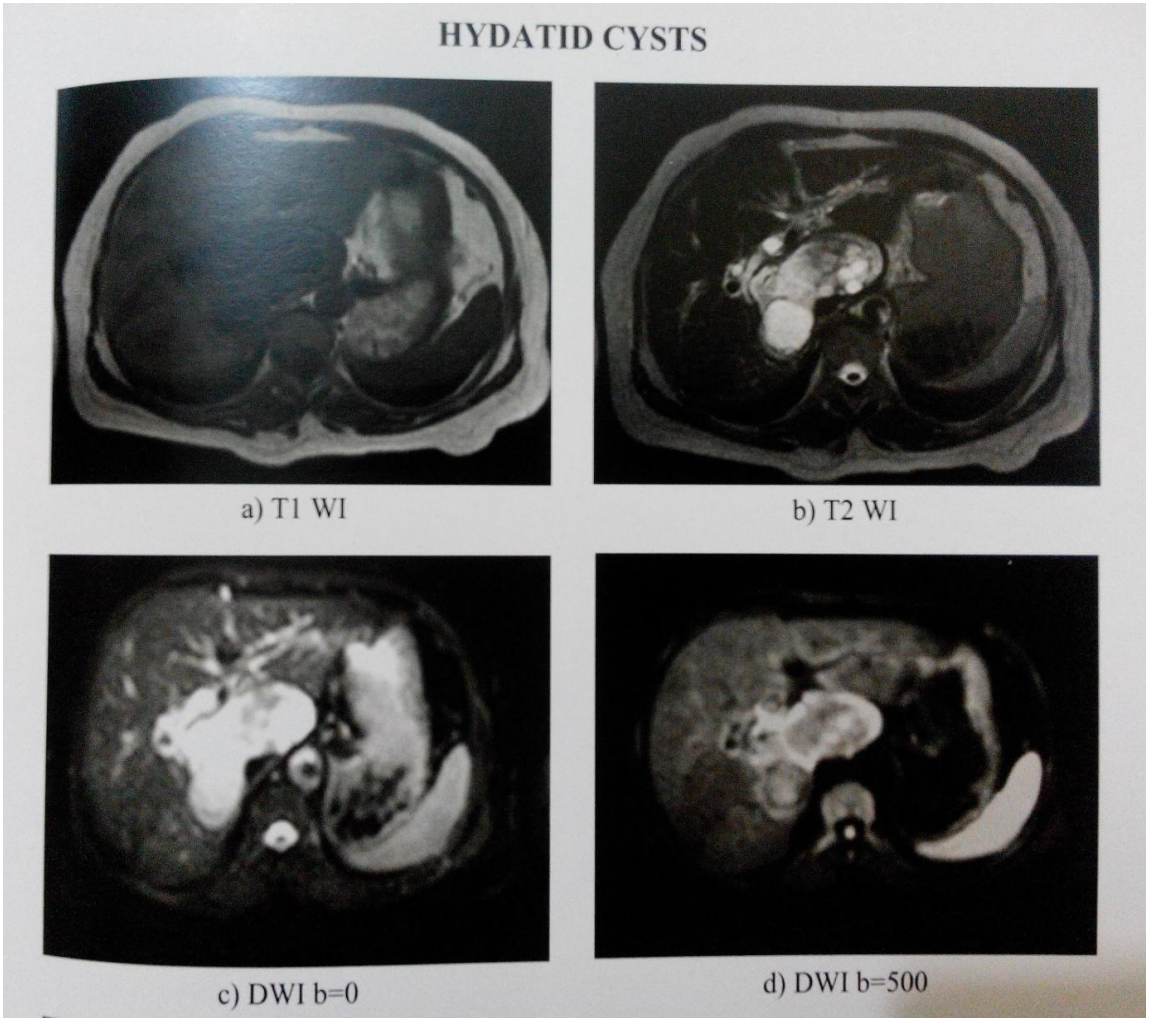


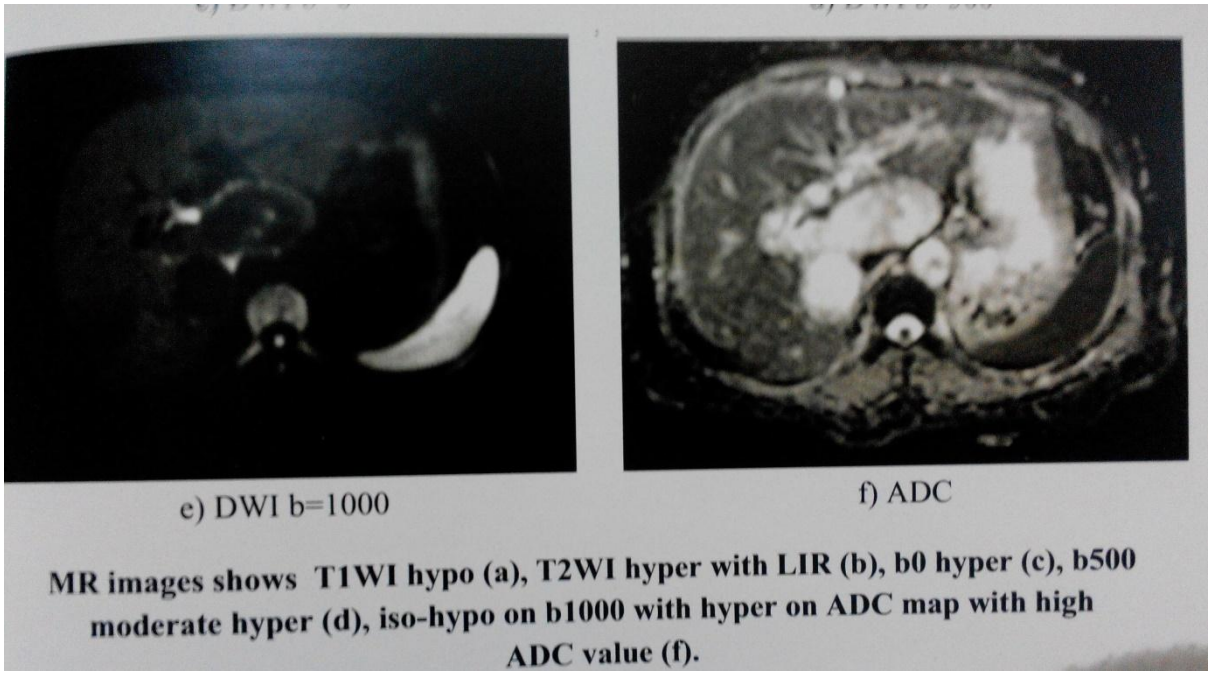
e) ADC

f) Post contrast T1WI venous phase

MR images of metastases showing multiple hyperintense on T1WI and b0 (a-b) and remains hyperintense on b500/1000 (c-d) (arrows) and hypointense on ADC map with low ADC value (e), post contrast lesions are hypovascular. Some lesions (arrow) showing peripheral rim hyperintense on diffusion

Fig.3



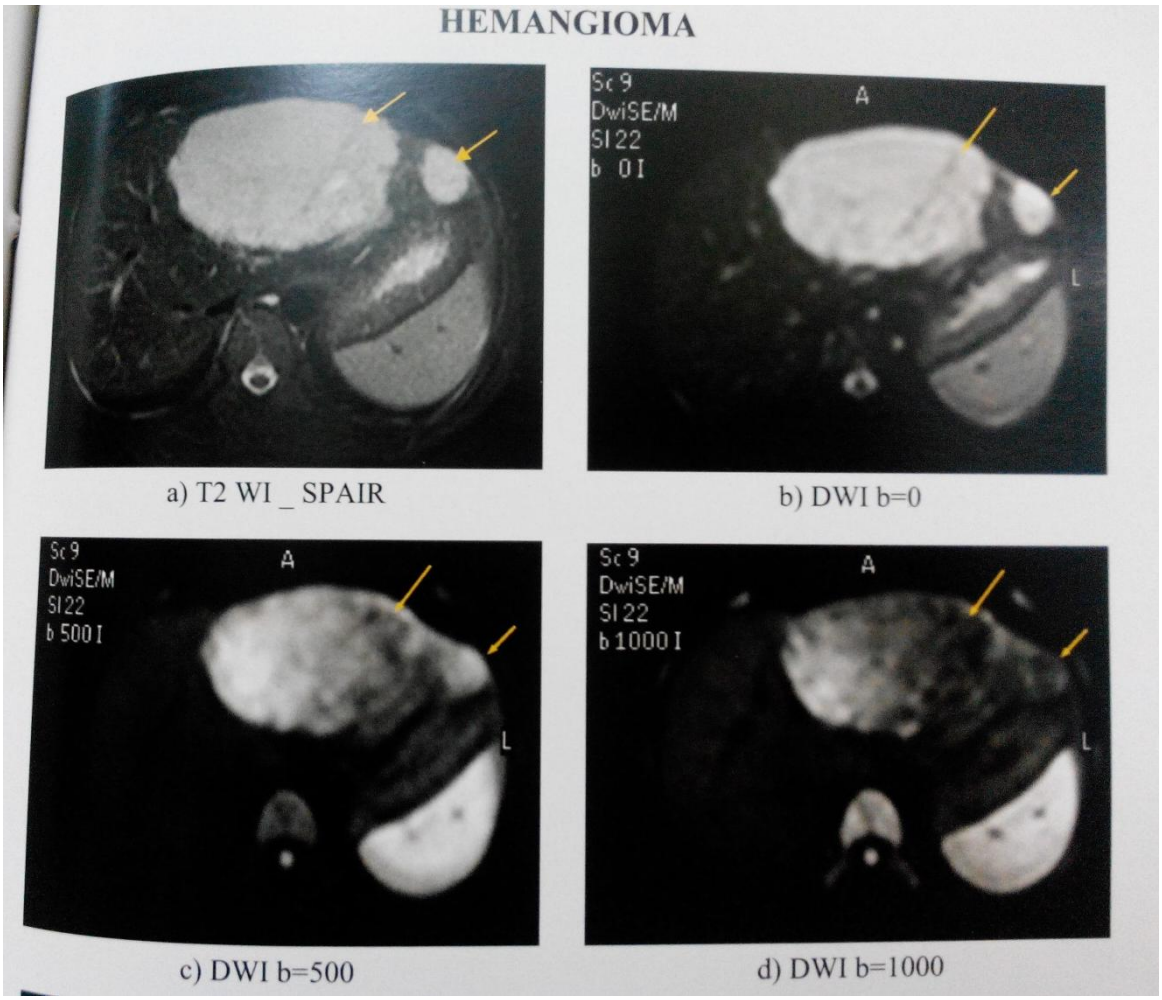


e) DWI b=1000

f) ADC

MR images shows T1WI hypo (a), T2WI hyper with LIR (b), b0 hyper (c), b500 moderate hyper (d), iso-hypo on b1000 with hyper on ADC map with high ADC value (f).

Fig.4

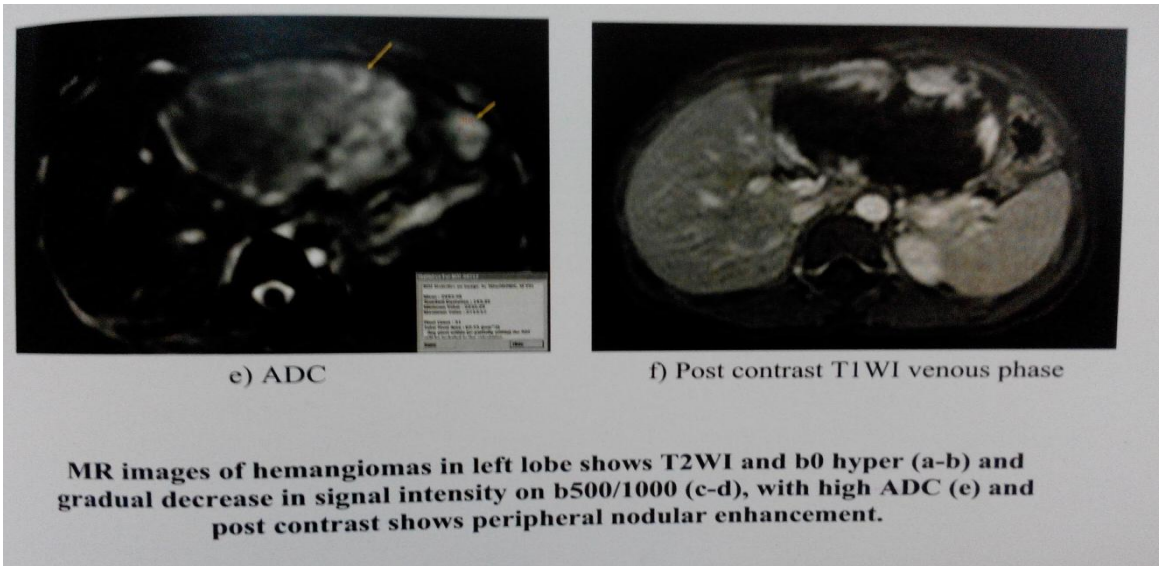


a) T2 WI _ SPAIR

b) DWI b=0

c) DWI b=500

d) DWI b=1000

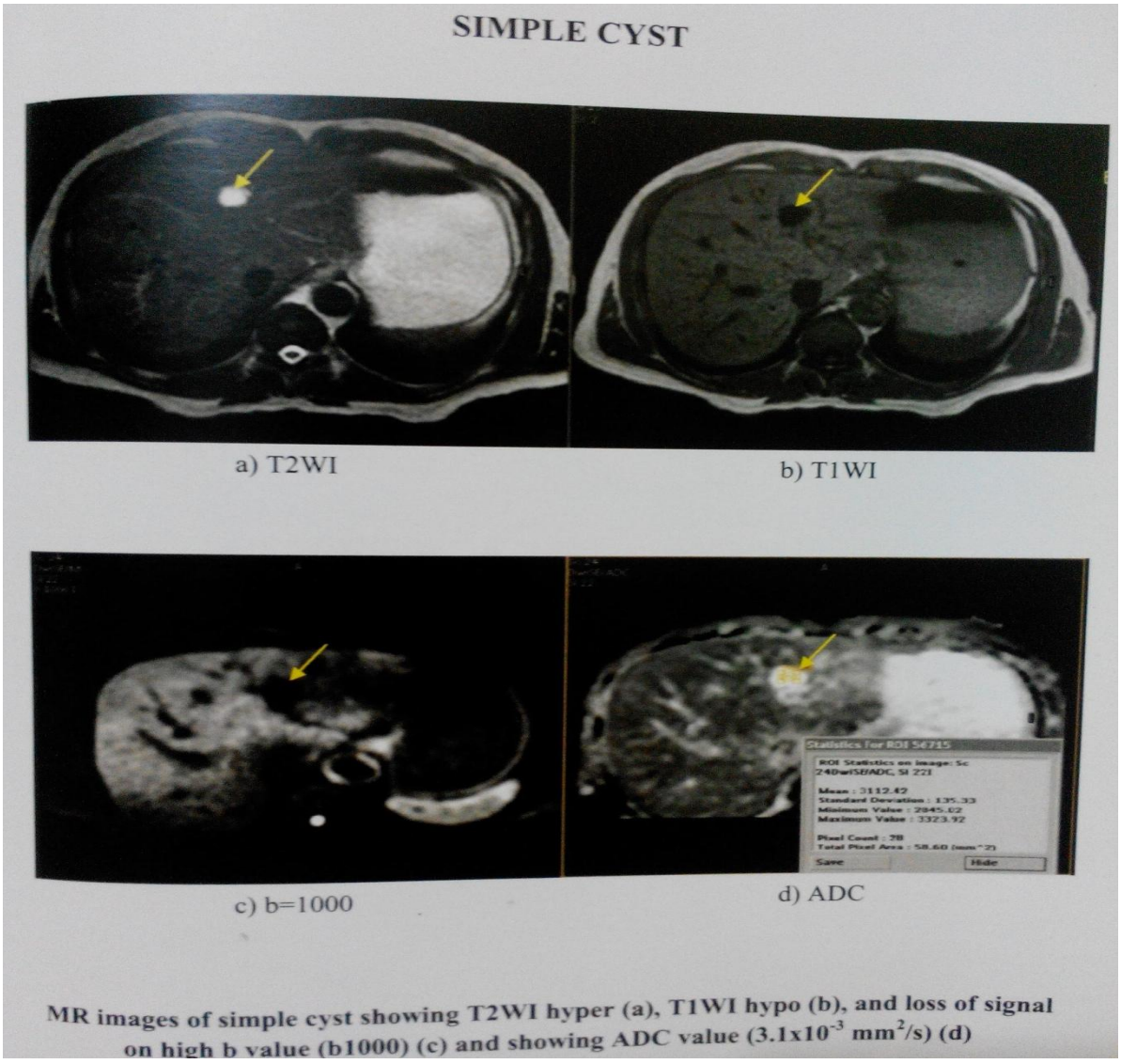


e) ADC

f) Post contrast T1WI venous phase

MR images of hemangiomas in left lobe shows T2WI and b0 hyper (a-b) and gradual decrease in signal intensity on b500/1000 (c-d), with high ADC (e) and post contrast shows peripheral nodular enhancement.

Fig.5



MR images of simple cyst showing T2WI hyper (a), T1WI hypo (b), and loss of signal on high b value (b1000) (c) and showing ADC value ($3.1x10^{-3}$ mm^2/s) (d)

Fig.6

Contribution Details (to be ticked marked as applicable):

	Contributor 1	Contributor 2	Contributor 3	Contributor 4
Concepts	◦	◦		
Design	◦	◦		
Definition of intellectual content	◦			
Literature search	◦	◦		
Clinical studies	◦	◦		
Experimental studies				
Data acquisition	◦			
Data analysis	◦			
Statistical analysis				
Manuscript preparation	◦	◦		
Manuscript editing	◦	◦		
Manuscript review		◦		
Guarantor		◦		