Role of Diffusion Weighted Imaging and ADC Values in Characterization of Focal Hepatic Lesions

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Abstract

Background: Liver MRI is commonly used for detection and evaluation of focal liver lesions (FLL). Diffusion weighted imaging (DWI) is a functional MR imaging which qualitatively and quantitatively assess the diffusion property of lesion. DWI is a fast sequence that does not require contrast administration. So, it can be used safely as an alternative to contrast sequence in renal insufficiency patients. The study was done to evaluate the role of DWI in characterization of focal liver lesions and differentiation of benign and malignant lesions.

Materials & Methods: 40 patients with 52 liver lesions were evaluated with diffusion weighted imaging at tertiary level hospital on 3T Philips Achieva MRI machine. Informed consents were obtained from patients. DWI of liver was done using three b values (0, 500, 1000 sec/mm^2). Qualitative and quantitative assessment of FLL was done using DWI and ADC map. All relevant clinical history, laboratory reports (AFP level), findings on other imaging modalities (USG, CT scan) and biopsy/FNAC were considered for final diagnosis of focal liver lesions.

Results: On qualitative analysis, all malignant lesions & abscesses showed restricted diffusion. Most of benign lesions disappeared on higher b values except one hemangioma & all abscesses. On quantitative analysis, mean ADC values for different lesions were obtained. There was significant difference ($p<0.0001$) between mean ADC value of malignant (1.02 $x10^{-3}$ mm^2/s) and benign (1.87$x10^{-3}$ mm^2/s) lesions. ADC cut off value of 1.42 $x10^{-3}$ mm^2/s for differentiating benign and malignant liver lesions was obtained with sensitivity of 96.3% and specificity of 72.0%.

Conclusion: Qualitative and quantitative assessment of diffusion weighted images and ADC map in addition to conventional MRI could be used in characterization of focal hepatic lesions and in differentiation between benign and malignant focal liver lesions.

Key words: Diffusion weighted imaging, Focal liver lesion, ADC map, MRI.

Introduction

Focal liver lesion (FLL) is any lesion in the liver other than the normal parenchyma. Cyst, hemangioma, focal nodular hyperplasia (FNH) and hepatocellular adenoma (HCA) are the most common benign focal liver lesions [1-4]. The most common malignant lesion in non cirrhotic liver is metastasis [5,6]. Hepatocellular carcinomas (HCC) and intrahepatic cholangiocarcinomas (IHC) occur mainly in the chronic liver disease and are the most common primary liver malignancies [6,7].

Different imaging modalities like ultrasound (USG), computed tomography (CT) and magnetic resonance imaging (MRI) are used for evaluation of focal liver lesions. Dynamic contrast enhanced MRI of liver is commonly done for focal liver lesion characterization. MRI is a non ionising imaging modality which has high soft tissue contrast resolution and safer contrast agents [8,9]. Diffusion weighted imaging (DWI) is a functional imaging technique which provides qualitative and quantitative assessment of diffusion properties of water molecules within tissue [10-12]. Diffusion weighted imaging was first used in brain [10]. Recently it is also used for evaluation of extra cranial organs like breast, liver, kidneys, prostate and whole body imaging in cancer patients. DWI is a fast sequence and does not require administration of contrast medium [12]. Diffusion weighted images should be obtained with conventional sequences. In patients whom gadolinium based contrast agents cannot be given, diffusion weighted MRI can be used as alternative technique to contrast enhanced imaging [12].

The study was done to evaluate the role of diffusion weighted imaging in characterization, detection of liver lesions and differentiating benign from malignant liver lesions confidently so that the need of contrast agents and FNAC/ biopsy could be reduced.

Material and Method

In this study we included 40 patients with 52 focal liver lesions which were evaluated with diffusion weighted MR imaging at tertiary level hospital. Institutional ethics committee approved the study. Informed consent was obtained from patients. All relevant clinical history, laboratory reports (AFP level), findings on other imaging modalities (USG, CT scan) and biopsy/FNAC were considered for final diagnosis of focal liver lesions.

Patients with clinically suspected liver lesions and patients with liver lesions detected on USG/CT were included in study. Patients having cochlear implants, cardiac pacemakers, any metallic implants and claustrophobic patients were excluded from study. MR imaging was done on 3 Tesla Philips Achieva MRI machine using torso coil.

Conventional axial T1 weighted and T2 weighted images were obtained. In addition respiratory triggered fat suppressed single shot echo planar diffusion weighted imaging was planned in axial plane by using three b values (b=0 s/mm 2 , b=500 s/mm2 and b=1000 s/mm2). Region of interest (ROI) was drawn on ADC map to calculate ADC value of each liver lesion.

MedCalc v12.7.5.0 software was used for statistical calculations. Independent sample t-test and independent sample Welch test for unequal variances were also used. ROC curve analysis was done using MedCalc v12.7.5.0. p value of < 0.05 was considered statistically significant.

Results

In the present study majority patients were in the age group of 51-60 years. Mean age of patients in the study was 52.7 years. The study population had 30 male and 10 female patients. It was noted that focal liver lesions were easier to detect on lower b value DWI sequence, as lesion showed higher signal intensity than surrounding liver parenchyma.

In the current study, most of the patients had metastasis (12 patients), followed by HCC (9 patients) and simple cyst (8 patients). In the sample size of 40 patients, 21 patients had malignant and 19 patients had benign lesions. In the present study 51.9% lesions were malignant and 48.1% lesions were benign out of 52 lesions for 40 patients. In the present

study most common lesions were metastasis, 18 lesions (34.6%). Distribution of liver lesions according to diagnosis is shown in table 1. All lesions were predominantly observed in male patients.

In the present study, all malignant lesion including HCC (9 lesions) and metastasis (18 lesions) showed hyperintense signal on DWI at all b values and hypointense signal on ADC map suggestive of restricted diffusion. Out of total 6 haemangioma of study, 5(83%) showed hyperintense signal intensity on DWI at all b values. One hemangioma become hypointense at b=1000sec/mm^2. However, no haemangioma showed restricted diffusion on ADC map. Out of total 10 simple cysts, 6(60%) cysts become hypointense at b=500 sec/mm^2 and all cysts become hypointense at higher b value (1000sec/mm^2). All cysts showed hyperintense signal intensity on ADC map suggestive of no restricted diffusion. Two cases of hydatid cysts become hypointense at b=1000 sec/mm^2 and showed hyperintense signal intensity on ADC map (no restricted diffusion). All abscesses (6 lesions) showed heterogeneous hyperintense signal intensity at all b values and showed restricted diffusion on ADC map. Only one case of hepatic adenoma was included in study which showed isointense signal intensity compared to liver parenchyma on both DWI and ADC map.

In this study, 11 benign lesions (44%) from total 25 benign lesions showed hyperintense signal at b=1000sec/mm^2 and 13(52%) benign lesions become hypointense at higher b values (500sec/mm^2 and/or 1000sec/mm^2) on DWI.. All malignant lesions showed restricted diffusion while all benign lesions except abscesses (24%) did not show restricted diffusion.

In this study we found that benign lesions had higher mean ADC value compared to malignant lesions. Max mean ADC value of 2.83 × 10^{-3} mm^2/sec was found in hydatid cyst followed by simple cyst with mean ADC value of 2.39 ×10^{-3} mm^2/sec. HCC had the lowest mean ADC value of 0.91 ×10-3mm^2/sec in malignant lesions. Metastasis had mean ADC value of 1.07 ×$10^{-3}$$mm^2$/sec. Table 2 shows the mean and SD of ADC value for malignant and benign lesions. Using independent sample t test, p-value < 0.05 was obtained showing significant difference between mean ADC values for malignant and benign lesions. Significant difference between mean ADC values for HCC and metastasis was obtained after applying independent sample Welch test for unequal variances, p value < 0.05 was found [table 3].

ADC cut-off value of 1.42 x 10^{-3} mm^2/sec was calculated by normal distribution to differentiate benign and malignant focal liver lesions. ROC curve (shown in figure 1) analysis gave sensitivity of 96.3% and specificity of 72.0% for this ADC cut off value.

Discussion

Diffusion weighted imaging is a simple and sensitive sequence in detection and characterization of focal liver lesions. In this study, all focal liver lesions at lower b value images were easy to detect as they showed higher signal intensity compared to surrounding liver parenchyma. Aliya, etal [13] and Parikh,et al [14] also concluded that detection of liver lesion is higher at low *b* values (50–150 s/mm^2). Higher b values are useful for liver lesion characterization; however this should be interpreted with other conventional MRI sequences. In this study all malignant lesions (HCC and metastasis) showed higher signal at all b values with hypointense signal on ADC map (Figure 2 and 3). Parikh, et al [14] also stated that malignant liver lesion showed hyperintense signal at b=500sec/mm^2 and lower ADC value than that of surrounding liver.

In this study five out of six haemangioma showed hyperintense signal on higher b values. However all hemangioma (figure 4) and cysts (figure 5) showed high ADC values without diffusion restriction. Jahic E, etal also reported that cysts and hemangiomas have the highest ADC values due to free movement of water molecules within while HCC, metastases and FNH showed the lowest value because of its high cellularity [15]. In this study all six abscesses showed restricted diffusion. Chan, et al [16] in their study also reported that all abscesses had hyperintense signal on DWI and hypointense signal on ADC maps.

We found 1.87×10^{-3} mm^2/sec mean ADC value for benign lesions and 1.02×10^{-3} mm^2/sec mean ADC value for malignant lesion. There was significant difference between mean ADC value for malignant and benign lesions in the studied sample. Similarly there was significant difference between mean ADC values for HCC and metastasis. Previous studies done by Onura, et al [17] and Miller, et al [18] also stated that the mean ADC values of benign lesions were higher than malignant lesions and these differences were statistically significant. Taouli, et al [19] showed that HCC and metastases had significant difference between mean ADC values.

ADC cut-off value of 1.42 x 10^{-3} mm^2/s was calculated which showed sensitivity of 96.3% and specificity of 72.0%. Current study showed comparable results with previous studies. Filipe et al. also found ADC cut off value of $1.43x10^{-3}$ mm^2 /s for differentiating benign and malignant lesions and have concluded that the ADC value of malignant lesions is significantly lower compared to benign lesions [20]. Taouli and Koh on the work of review reported the results of various studies and found ADC cut-off ranging from 1.47 to 1.63 x 10^{-3} mm^2/s, useful for differentiation of benign from malignant lesions [10].

Limitation: Sample size of study was small and paediatric age group was excluded from study. Histopathological correlation was not done in all cases specially in benign lesions where alternative imaging findings and AFP levels were used for final diagnosis. DWI images at higher b values has poor spatial resolution and SNR thus make evaluation difficult.

Conclusion: Qualitative and quantitative assessment of diffusion weighted images and ADC map in addition to conventional MRI could be used in characterization of focal hepatic lesions and in differentiation between benign and malignant focal liver lesions, particularly in patients with renal impairment.

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Conflict of interest: None

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Tables

Diagnosis	Number of lesions	Percentage
HCC	9	17.3
Metastasis	18	34.6
Hemangioma	6	11.5
Simple cyst	10	19.2
Hydatid cyst	2	3.84
Abscess	6	11.5
Adenoma	1	1.92
Total	52	100

Table 1. Distribution of liver lesions according to diagnosis

Type of lesion	Number of lesions	ADC in 10^{-3} mm^2/sec		p value
		Mean	SD	
Malignant	27	1.02	0.22	<0.0001
Benign	25	1.87	0.78	

Table 2. Mean ADC value of malignant and benign lesions

Diagnosis	No. of lesions	ADC 10^{-3} x mm^2/sec		p value
		Mean	SD	
HCC	9	0.91	0.17	0.036
Metastasis	18	1.07	0.23	

Table 3.Mean ADC comparison between HCC and metastasis

Figures

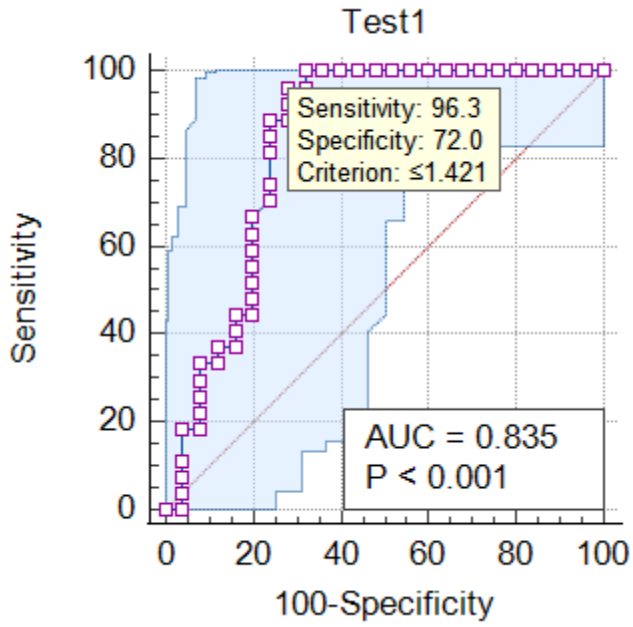

Figure 1. Sensitivity vs (100-specificity) chart is shown above generated by ROC curve analysis showing sensitivity, specificity and AUC.

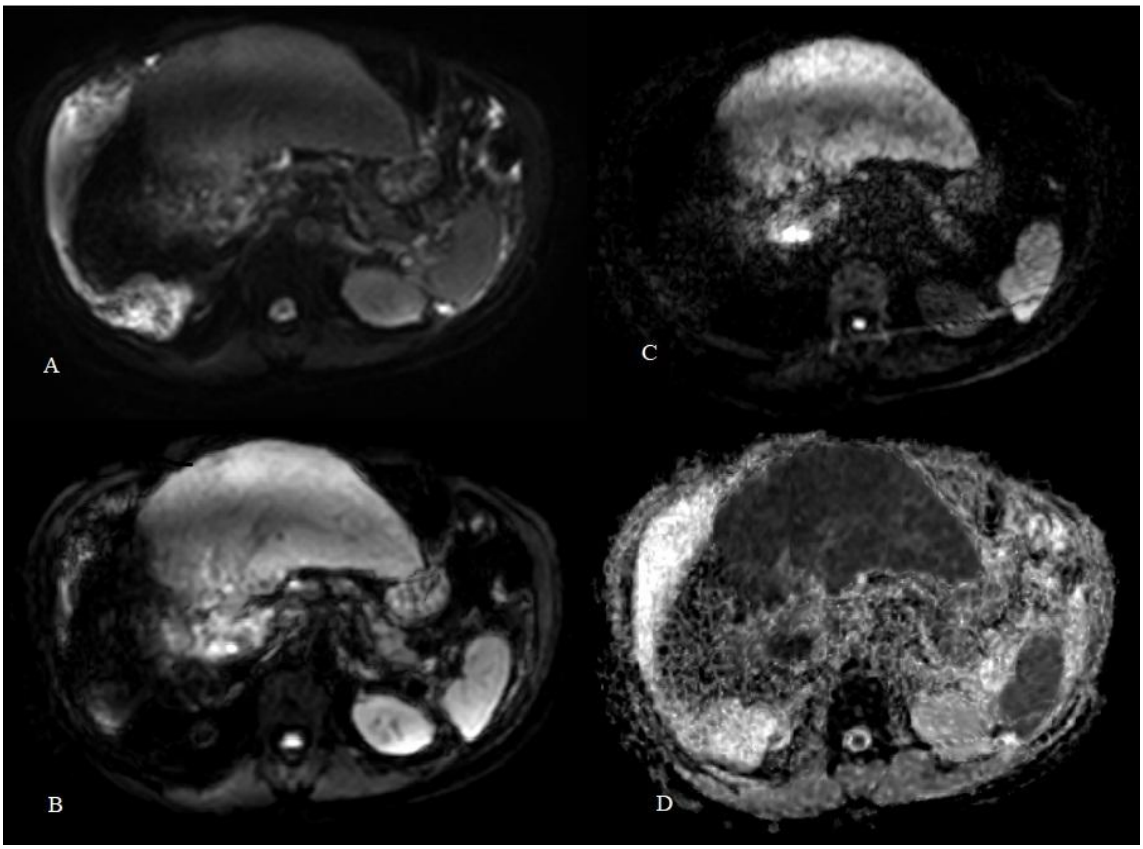

Figure 2. Large infiltrating HCC showing high signal on b value 500 and 1000 (2B and 2C) with hypo intense signal on ADC (2D) s/o restricted diffusion.

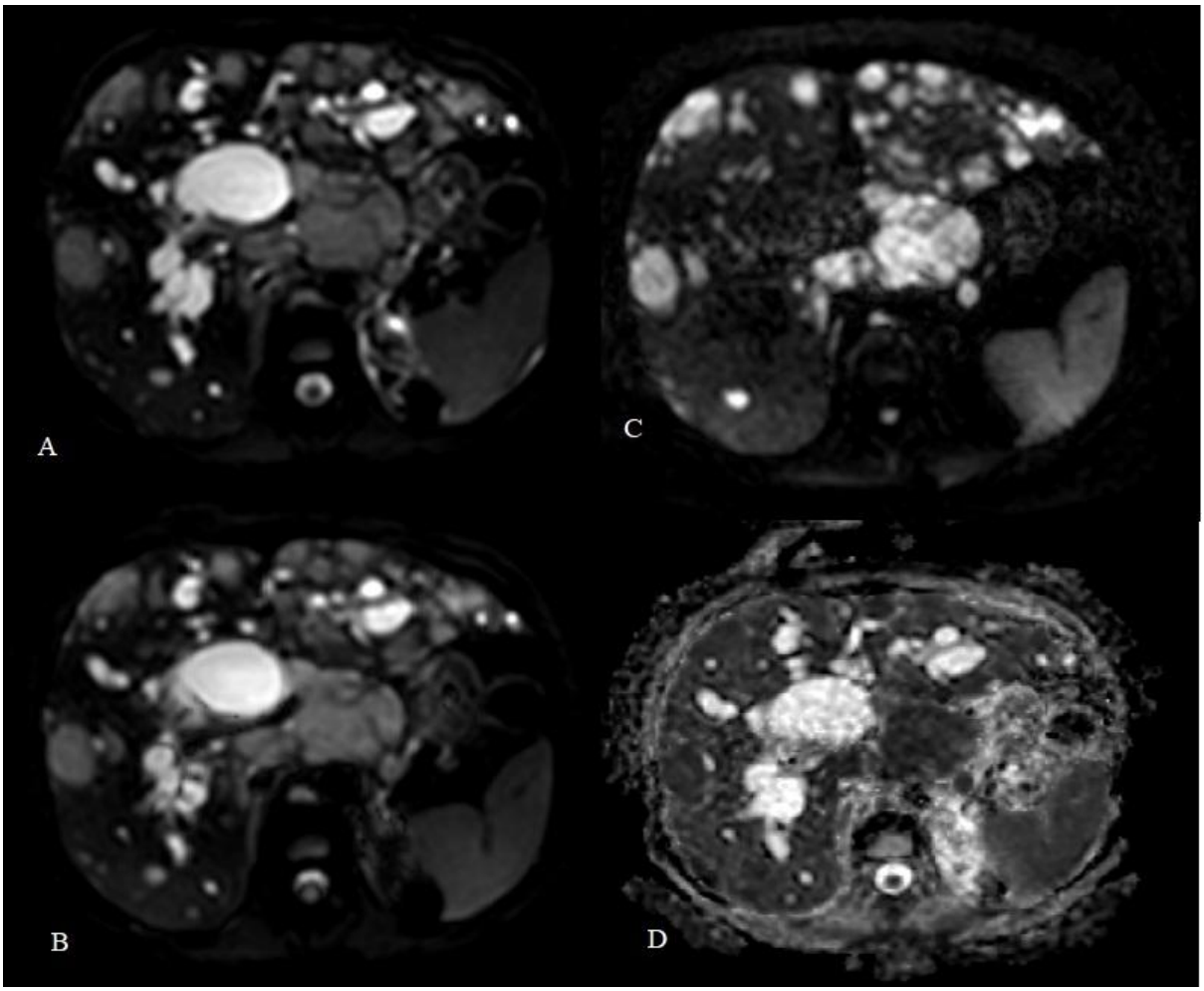

Figure 3.Mutiple focal hepatic lesions becoming more hyperintense on b 1000 DWI image (3C) and showing restricted diffusion (3D), on biopsy proved to be metastasis.

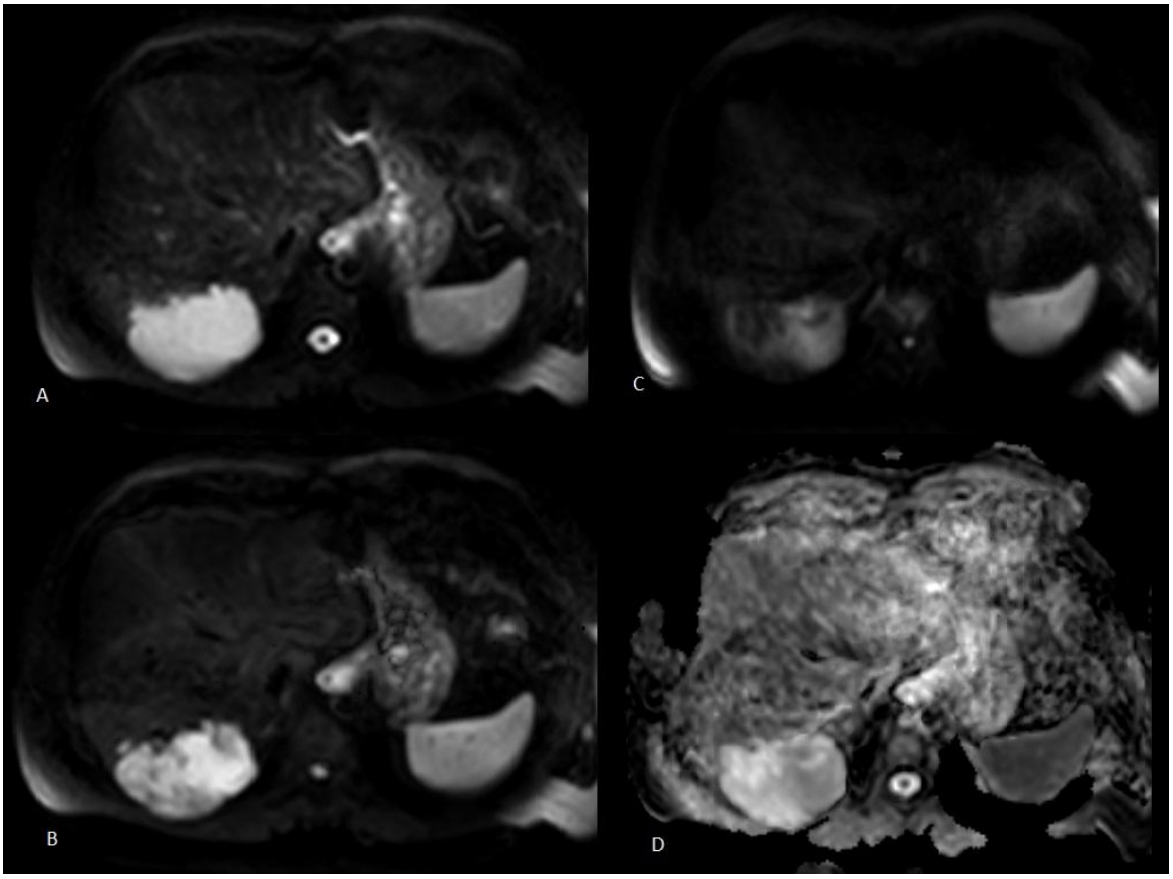

Figure 4.A case of hemangioma showing high signal on DWI at all b values (4A,4B,4C at 0,500,1000 b values) as well as on ADC (4D).

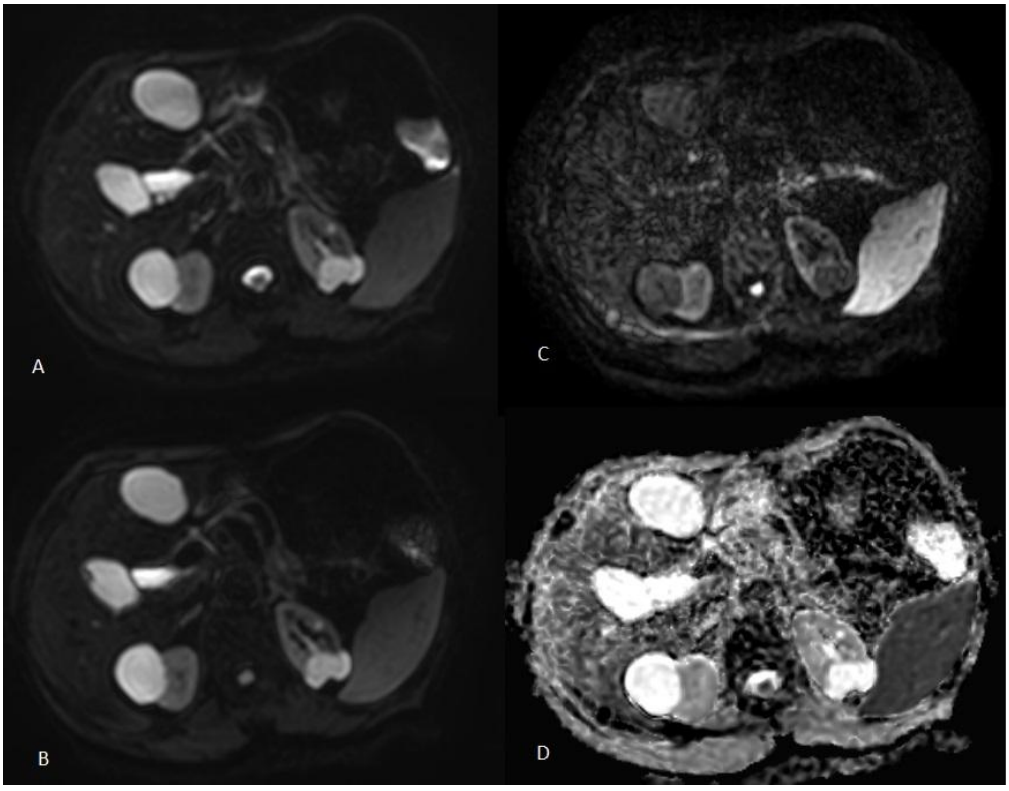

Figure 5.A well defined simple hepatic showing high signal at low b value DWI images (5A and 5B) and disappear at high b value (5C). No diffusion restriction is seen on ADC (5D).