The role of MRI diffusion weighted images in assessment of benign and malignant hepatic focal lesions in non paediatric age group

Poster No.: C-2002
Congress: ECR 2016
Type: Scientific Exhibit
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Keywords: Abdomen, Liver, MR-Diffusion/Perfusion, MR, Molecular imaging, Neoplasia, Tissue characterisation, Cancer
DOI: 10.1594/ecr2016/C-2002

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Aims and objectives

Introduction

The liver is an organ in which various benign, malignant primary or secondary focal lesions can be detected. Hepatic focal lesions constitute a daily challenge in clinical setting and due to its high prevalence and the ever-increasing demand on radiologists to detect smaller tumors, when curative therapies are most effective. The diagnosis and characterization of these lesions are important objectives in diagnostic imaging (1).

Liver magnetic resonance imaging (MRI) has been used in problematic cases where ultrasound or CT findings are equivocal. Currently MRI established its role in imaging setting of focal hepatic lesions as biopsy is no longer required prior to treatment and diagnosis of focal hepatic lesions is heavily dependent on imaging characteristics as established by the most recent recommendations in literature (1).

Diffusion-weighted imaging (DWI) established an important role in clinical use in the abdomen, particularly in the liver. DWI can potentially add useful qualitative and quantitative information to conventional imaging sequences. It is a non-enhanced fast technique and can be easily incorporated to existing protocols (2).

Objectives

To assess the role of diffusion-weighted imaging (DWI) in detection and characterization of hepatic focal lesions and its value to differentiate benign from malignant masses.
Methods and materials

Patients and Methods

Patients

The study included 60 patients, 39 females and 21 males, their ages ranged from 20 to 63 years. All patients underwent detailed MRI study of the abdomen.

MRI protocol

The MR examination was performed on high field system 1.5 Tesla-magnet unit and the study included conventional MRI, diffusion and post Gd-DTPA dynamic MR imaging.

The conventional study included T1, T2, heavy T2, in phase and out phase sequences.

Dynamic study was performed after bolus injection of 0.1mmol/kg body weight of Gd-DTPA at a rate of 2ml/s, flushed with 20ml of sterile 0.9% saline solution from the antecubital vein. Dynamic imaging using ultra-fast T1 fat-suppressed sequence including pre-contrast injection, arterial phase (16-20 sec.), arterio-portal phase (20-40 sec.) and porto-venous phase (45-60 sec.). This was followed by delayed phase (2-3 min.) after contrast injection.

Diffusion study was performed using respiratory-triggered fat-suppressed single-shot echoplanar. DW imaging was performed in the transverse plane with tri-directional diffusion gradients by using b values 0, 500 and 1000 sec/mm$^2$ to increase sensitivity to cellular packing. The other parameters were as follows: repetition time (TR) #1880 msec, echo time (TE) = 70 msec, number of excitations (NEX)=3, matrix 256x256 with a field of view as small as possible with 52% rectangular field of view, slice thickness 7-8mm, slice gap 1-2mm, scan time 3-4min.

Image analysis

Imaging evaluation assessed the morphological features of each lesion including size, shape, margin, signal characteristics and dynamic pattern of enhancement as well as number and site of the detected focal lesions. Then provisional diagnosis was reported.
Second, we reviewed the diffusion images for final radiological characterization and detection of focal lesions.

ADC maps and values were calculated for all lesions. One region of interest (1 cm) was applied to small lesions. For large lesions few regions of interest were applied and ADC measurements were averaged. The ADC data was accomplished by an automated application available on the scanner.

The final diagnoses were reached according to Standard of reference (SOR). The SOR included two different imaging modalities, laboratory, clinical and histopathological data.
Results

Our study included 60 patients, 39 females (65%) and 21 males (35%). The patients’ age ranged from 20 to 63 years old with most of the patients lying in the group of 50 years and above. 40 lesions were found in the 60 patients. 20 lesions were benign lesions and 20 were malignant.

The 20 benign lesions were cysts, hemangiomas and adenomas. The 20 malignant lesions were HCC, cholangiocarcinoma and metastasis (table 1).

Most of benign lesions showed facilitated diffusion, where they showed reduction of signal intensity on increasing the b-values and those which did not show reduction of signal demonstrated high signal on ADC map, which also reflects facilitated diffusion.

On the other hand all malignant lesions showed restricted diffusion evidenced by increased signal on increasing the b-values and low signal on ADC maps.

Mostly benign lesions show higher ADC values than malignant lesions.

The average ADC value for cysts was $2.71 \times 10^{-3}$ (9 lesions; 22.5%) (fig. 1-7).

The average ADC value for hemangiomas was $2.1 \times 10^{-3}$ (8 lesions; 20%) (fig. 8-14)

The average ADC value for adenomas was $1.32 \times 10^{-3}$ (3 lesions; 7.5) (fig. 15-20)

The average ADC value for hepatocellular carcinomas was $1.25 \times 10^{-3}$ (7 lesions; 17.5 %) (fig. 21-26)

The average ADC value range for cholangiocarcinomas was $1.54 \times 10^{-3}$ (3 lesions; 7.5 %) (fig. 27-35)
The average ADC value range for metastasis was $0.97 \times 10^{-3}$ (10 lesions; 25%) (fig. 36-42).

However relatively high ADC values were encountered in few malignant lesions (three cholangiocarcinomas and two hepatocellular carcinomas) measuring $1.4 \times 10^{-3}$ to $1.79 \times 10^{-3}$.

The above mentioned data denotes with an overlap range of ADC values between adenomas and few malignant lesions with no definite cut off for the ADC value.

<table>
<thead>
<tr>
<th>Type of lesion</th>
<th>number</th>
<th>percentage</th>
<th>ADC range</th>
</tr>
</thead>
<tbody>
<tr>
<td>cyst</td>
<td>9</td>
<td>22.5%</td>
<td>$2.71 \times 10^{-3}$</td>
</tr>
<tr>
<td>hemangioma</td>
<td>8</td>
<td>20%</td>
<td>$2.1 \times 10^{-3}$</td>
</tr>
<tr>
<td>adenoma</td>
<td>3</td>
<td>7.5%</td>
<td>$1.32 \times 10^{-3}$</td>
</tr>
<tr>
<td>hepatocellular carcinoma</td>
<td>7</td>
<td>17.5%</td>
<td>$1.25 \times 10^{-3}$</td>
</tr>
<tr>
<td>cholangiocarcinoma</td>
<td>3</td>
<td>7.5%</td>
<td>$1.54 \times 10^{-3}$</td>
</tr>
<tr>
<td>metastasis</td>
<td>10</td>
<td>25%</td>
<td>$0.97 \times 10^{-3}$</td>
</tr>
</tbody>
</table>

**Table (1)** shows different types of focal hepatic lesions, their number, percentage and ADC range.
Images for this section:

**Fig. 1:** Fig. 1, 2, 3 coronal, axial T2WIs and axial T1WI show multiple variable sized hepatic cystic lesions mostly within the left hepatic lobe, eliciting low T1 and bright T2 signal. Diagnosis: Hepatic cysts.

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**Fig. 2:** Fig. 1, 2, 3 coronal, axial T2WIs and axial T1WI show multiple variable sized hepatic cystic lesions mostly within the left hepatic lobe, eliciting low T1 and bright T2 signal. Diagnosis: Hepatic cysts.

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**Fig. 3:** Fig. 1, 2, 3 coronal, axial T2WIs and axial T1WI show multiple variable sized hepatic cystic lesions mostly within the left hepatic lobe, eliciting low T1 and bright T2 signal. Diagnosis: Hepatic cysts.

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Fig. 4: Fig. 4, 5, 6, 7 diffusion WIs b0, b500, b1000, and ADC map respectively showing multiple variable sized bright hepatic focal lesions in the diffusion images with reduced brightness when increasing the b value with persistent brightness in the ADC map denoting facilitated diffusion. ADC values: ranging from 2.54x10^-3 to 2.81x10^-3 mm^2/ sec. Diagnosis: Hepatic cysts.

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Fig. 5: Fig. 4, 5, 6, 7 diffusion Wls b0, b500, b1000, and ADC map respectively showing multiple variable sized bright hepatic focal lesions in the diffusion images with reduced brightness when increasing the b value with persistent brightness in the ADC map denoting facilitated diffusion. ADC values: ranging from 2.54x10^{-3} to 2.81x10^{-3} mm^2/sec. Diagnosis: Hepatic cysts.

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Fig. 6: Fig. 4, 5, 6, 7 diffusion Wls b0, b500, b1000, and ADC map respectively showing multiple variable sized bright hepatic focal lesions in the diffusion images with reduced brightness when increasing the b value with persistent brightness in the ADC map denoting facilitated diffusion. ADC values: ranging from $2.54 \times 10^{-3}$ to $2.81 \times 10^{-3}$ mm$^2$/sec. Diagnosis: Hepatic cysts.

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**Fig. 7:** Fig. 4, 5, 6, 7 diffusion WIs b0, b500, b1000, and ADC map respectively showing multiple variable sized bright hepatic focal lesions in the diffusion images with reduced brightness when increasing the b value with persistent brightness in the ADC map denoting facilitated diffusion. ADC values: ranging from $2.54 \times 10^{-3}$ to $2.81 \times 10^{-3}$ mm$^2$/sec. Diagnosis: Hepatic cysts.

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**Fig. 8:** Fig. 8, 9 axial T1 and T2 respectively, show an irregular shaped focal lesion implicating the postero-inferior segment of the right hepatic lobe, eliciting low T1 and increased T2 signal with central area of breaking down within eliciting fluid signal. Diagnosis: Hemangioma.

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**Fig. 9:** Fig. 8, 9 axial T1 and T2 respectively, show an irregular shaped focal lesion implicating the postero-inferior segment of the right hepatic lobe, eliciting low T1 and increased T2 signal with central area of breaking down within eliciting fluid signal. Diagnosis: Hemangioma.

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Fig. 10: Fig. 10, 11, 12 axial T1 post contrast Arterial, porto-venous and delayed phases respectively, showing post contrast peripheral marginal enhancement in the arterial phase with centripetal pattern of enhancement in the portovenous and delayed phase giving a closed iris appearance. Diagnosis: Hemangioma.

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**Fig. 11:** Fig. 10, 11, 12 axial T1 post contrast Arterial, porto-venous and delayed phases respectively, showing post contrast peripheral marginal enhancement in the arterial phase with centripetal pattern of enhancement in the portovenous and delayed phase giving a closed iris appearance. Diagnosis: Hemangioma.

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**Fig. 12:** Fig. 10, 11, 12 axial T1 post contrast Arterial, porto-venous and delayed phases respectively, showing post contrast peripheral marginal enhancement in the arterial phase with centripetal pattern of enhancement in the portovenous and delayed phase giving a closed iris appearance. Diagnosis: Hemangioma.

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**Fig. 13:** Fig. 13, 14 axial DWIs b500 and ADC map showing a low diffusion and bright ADC signal consistent with facilitated diffusion. Average ADC values for this lesion was $2.2 \times 10^{-3}$. Diagnosis: Hemangioma.

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Fig. 14: Fig. 13, 14 axial DWIs b500 and ADC map showing a low diffusion and bright ADC signal consistent with facilitated diffusion. Average ADC values for this lesion was 2.2 x 10^-3. Diagnosis: Hemangioma.

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Fig. 15: Fig. 15, 16 coronal and axial T2 WIs show a right hepatic lobe hyperintense focal lesion. Diagnosis adenoma

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**Fig. 16:** Fig. 15, 16 coronal and axial T2 WIs show a right hepatic lobe hyperintense focal lesion. Diagnosis: adenoma

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Fig. 17: Fig. 17 axial T1 fat suppression showing the reduced signal of the lesion suggesting fatty content. Diagnosis: adenoma

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Fig. 18: Fig. 18, 19, 20 axial diffusion WIs b0, b500 and b1000, showing the right hepatic lobe focal lesion hyperintense signal at the three different b values denoting restricted diffusion pattern. The ADC value for this lesion was 1.41 x 10^{-3} \text{ mm}^2/\text{sec}. Diagnosis: Adenoma

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**Fig. 19:** Fig. 18, 19, 20 axial diffusion WIs b0, b500 and b1000, showing the right hepatic lobe focal lesion hyperintense signal at the three different b values denoting restricted diffusion pattern. The ADC value for this lesion was $1.41 \times 10^{-3}$ mm$^2$/sec. Diagnosis: Adenoma

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**Fig. 20:** Fig. 18, 19, 20 axial diffusion WIs b0, b500 and b1000, showing the right hepatic lobe focal lesion hyperintense signal at the three different b values denoting restricted diffusion pattern. The ADC value for this lesion was $1.41 \times 10^{-3}$ mm²/sec. Diagnosis: Adenoma

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**Fig. 21:** Fig 21, 22 axial T1 and T2 WIs, show cirrhotic liver changes with a suspected fairly defined left hepatic lobe focal lesion. Diagnosis: hepatocellular carcinoma

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**Fig. 22:** Fig 21, 22 axial T1 and T2 WIs, show cirrhotic liver changes with a suspected fairly defined left hepatic lobe focal lesion. Diagnosis: hepatocellular carcinoma

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Fig. 23: Fig 23, 24 axial post contrast arterial and porto-venous phases respectively, showing the previously suspected left hepatic lobe area of abnormal signal intensity shows intense post contrast enhancement. Diagnosis: hepatocellular carcinoma

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Fig. 24: Fig 23, 24 axial post contrast arterial and porto-venous phases respectively, showing the previously suspected left hepatic lobe area of abnormal signal intensity shows intense post contrast enhancement. Diagnosis: hepatocellular carcinoma

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Fig. 25: Fig 25, 26 axial diffusion Wls b500 and B1000 showing a definite focal lesion which shows increasing brightness with increasing the b value. ADC value for this lesion was 1.05x10-3 mm2/sec. Diagnosis: hepatocellular carcinoma

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**Fig. 26:** Fig 25, 26 axial diffusion WIs b500 and B1000 showing a definite focal lesion which shows increasing brightness with increasing the b value. ADC value for this lesion was 1.05x10^{-3} mm^2/sec. Diagnosis: hepatocellular carcinoma

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Fig. 27: 27, 28 axial T1WI and T2WI, show a large irregular shaped infiltrative lesion seen implicating the anterior segments of the right hepatic lobe. Diagnosis: cholangiocarcinoma

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Fig. 28: 27, 28 axial T1WI and T2WI, show a large irregular shaped infiltrative lesion seen implicating the anterior segments of the right hepatic lobe. Diagnosis: cholangiocarcinoma

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**Fig. 29:** Fig. 29, 30, 31 axial T1 post contrast, arterial portal and porto-venous showing the ill-defined infiltrative lesion exhibiting faint enhancement in the arterial phase with increasing enhancement in the consecutive phases with hypointense foci of fluid signal intensity within. Diagnosis: cholangiocarcinoma

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Fig. 30: Fig. 29, 30, 31 axial T1 post contrast, arterial portal and porto-venous showing the ill-defined infiltrative lesion exhibiting faint enhancement in the arterial phase with increasing enhancement in the consecutive phases with hypointense foci of fluid signal intensity within. Diagnosis: cholangiocarcinoma

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Fig. 31: Fig. 29, 30, 31 axial T1 post contrast, arterial portal and porto-venous showing the ill-defined infiltrative lesion exhibiting faint enhancement in the arterial phase with increasing enhancement in the consecutive phases with hypointense foci of fluid signal intensity within. Diagnosis: cholangiocarcinoma

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Fig. 32: Fig 32, 33, 34, 35 axial DWIs b0, b500, b1000 and ADC map showing the lesion infiltrating the right hepatic lobe being bright in the diffusion images with the different b-values with few hypointense foci within and appear hypointense in the ADC images denoting restriction with few hyperintense foci within likely breaking down. ADC value: 1.51x10^{-3} \text{ mm}^2/\text{sec}. Diagnosis: Cholangiocarcinoma

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Fig. 33: Fig 32, 33, 34, 35 axial DWIs b0, b500, b1000 and ADC map showing the lesion infiltrating the right hepatic lobe being bright in the diffusion images with the different b-values with few hypointense foci within and appear hypointense in the ADC images denoting restriction with few hyperintense foci within likely breaking down. ADC value: 1.51x10^-3 mm²/sec. Diagnosis: Cholangiocarcinoma

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Fig. 34: Fig 32, 33, 34, 35 axial DWIs b0, b500, b1000 and ADC map showing the lesion infiltrating the right hepatic lobe being bright in the diffusion images with the different b-values with few hypointense foci within and appear hypointense in the ADC images denoting restriction with few hyperintense foci within likely breaking down. ADC value: 1.51x10^-3 mm²/sec. Diagnosis: Cholangiocarcinoma

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**Fig. 35:** Fig 32, 33, 34, 35 axial DWIs b0, b500, b1000 and ADC map showing the lesion infiltrating the right hepatic lobe being bright in the diffusion images with the different b-values with few hypointense foci within and appear hypointense in the ADC images denoting restriction with few hyperintense foci within likely breaking down. ADC value: 1.51x10^-3 mm²/sec. Diagnosis: Cholangiocarcinoma

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Fig. 36: Fig. 36, 37 axial and coronal T2WIs show a small hyperintense focal lesion seen within the posterior segment of the right hepatic lobe. Diagnosis: metastasis

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Fig. 37: Fig. 36, 37 axial and coronal T2WIs show a small hyperintense focal lesion seen within the posterior segment of the right hepatic lobe. Diagnosis: metastasis

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**Fig. 38:** Fig. 38, 39 axial T1WI before and after contrast injection showing no gross enhancement. Diagnosis: metastasis

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**Fig. 39:** Fig. 38, 39 axial T1WI before and after contrast injection showing no gross enhancement. Diagnosis: metastasis

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**Fig. 40:** Fig. 40, 41, 42 axial Diffusion b500 and B1000 and ADC map respectively showing increasing signal of the lesion with increased b value and dark signal in ADC map. ADC value for this lesion was: 1.04x10^-3 mm2/sec. Diagnosis: Metastasis

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**Fig. 41:** Fig. 40, 41, 42 axial Diffusion b500 and B1000 and ADC map respectively showing increasing signal of the lesion with increased b value and dark signal in ADC map. ADC value for this lesion was: 1.04x10^{-3} mm²/sec. Diagnosis: Metastasis

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**Fig. 42:** Fig. 40, 41, 42 axial Diffusion b500 and B1000 and ADC map respectively showing increasing signal of the lesion with increased b value and dark signal in ADC map. ADC value for this lesion was: $1.04 \times 10^{-3}$ mm$^2$/sec. Diagnosis: Metastasis

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Conclusion

Diffusion-weighted MRI sequence with quantitative ADC measurements should be used as an additional sequence to supplement conventional MRI protocol studies for proper characterization of focal hepatic lesions putting into consideration an overlap range.
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