Utility of diffusion-weighted MRI in distinguishing benign and malignant hepatic lesions

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Purpose

• To determine if focal liver masses could be differentiated as benign or malignant on the basis of diffusion-weighted imaging (DWI).

Methods and Materials

• A total of 45 patients with focal liver masses were scanned using 1.5 T magnetic resonance imaging (MRI). DWI was performed with b values of 0, 50, 400 and 600.

• The apparent diffusion coefficient (ADC) of the lesion was measured.

• The liver masses were diagnosed on histology or had characteristic computed tomography/MRI findings and follow up of more than 6 months.

• The analyzed lesions were hemangioma (n = 11), cysts (n = 10), hepatocellular cancer (HCC) (n = 5), hepatoblastoma (n = 1), focal nodular hyperplasia (FNH) (n = 1), and metastases (n = 17).

Results

• The mean ADC values of all the disease groups were statistically significant when compared with the mean ADC value of the normal liver.

• There were also statistically significant differences among the ADC values of hemangiomas and HCC, metastases, and simple cysts.

• However, there was no statistically significant difference between HCC and metastases.

Discussion:

• Several studies have suggested that the measurement of ADC values is useful in the characterization of focal liver lesions.

• Reduced ADC values have been reported for most malignant tumors. This finding is thought to be the result of cellular membranes impeding the mobility of water molecules.

• However, solid benign lesions, which are also highly cellular, exhibit decreased ADC values as well.
Abscesses do so too because their viscose content with bacteria, inflammatory cells, mucoid proteins and cell debris result in restricted diffusion, thus low ADC values.

On the other hand, necrotic and cystic malignancies show high ADC values resulting from larger diffusion distances as a consequence of lost membrane integrity.

Benign lesions as simple cysts and hemangiomas show high ADC values because of their liquid content and large extracellular spaces.

In the literature, ADC values vary between $0.94-2.85 \times 10^{-3}$ mm$^2$/s for metastases and $0.69-2.28 \times 10^{-3}$ mm$^2$/s for normal liver parenchyma.

This is mainly because every study group uses their own scanning parameters.

Differences in b-values are the main cause of nonequivocal results. Breath-hold, respiratory triggered and navigator echo techniques can also give different ADC values.

There is need for an uniformly applicable scanning protocol to eliminate discrepancies in ADC values caused by different scanning parameters.

DWI alone is not suitable for the characterization of liver lesions, because solid benign lesions also can show restricted diffusion, and cystic or necrotic malignant lesions have unimpeded diffusion.

DWI can help direct the attention of the radiologist to findings that may otherwise be overlooked.

Unenhanced and dynamic MRI contrast series alone are very capable in the discrimination of different types of liver lesions, but a combination of DWI and MRI increases the accuracy of the characterization of benign and malignant lesions.

**Detection of hepatocellular carcinoma (HCC):**

Large HCC lesions are well-recognized on conventional MRI by their rapid enhancement in the arterial phase and their contrast agent wash-out in the portal-venous phase.

Small HCC is less typical on conventional MRI, and differentiation of atypical nodules in the cirrhotic liver is challenging.

Xu and al found that ADC values were not useful in cirrhotic livers, because cirrhotic parenchyma and solid benign lesions have low ADC values.

They cannot be differentiated from lesions with malignant diffusion restriction because of the considerable overlap among their ADC values.

Necrosis and vascularization within HCC also alter diffusion, often seen as a false increase in the ADC values.
• Zech and al reported a higher sensitivity for DWI compared to conventional MRI in the detection of HCC in the cirrhotic liver (98% for DWI vs 83%-85% for MRI).

• Vandecaveye et al 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.

• These findings can be explained by the better contrast-to-noise ratio and background suppression of normal liver parenchyma and vascular or bile structures in DWI, which make small lesions more visible, especially when they are in close vicinity to vessels or bile ducts.

• DWI provides a high negative predictive value on the presence or absence of HCC and reduces the rate of unnecessary invasive diagnostic procedures and follow-up.

Detection of liver metastases:

• Several studies have demonstrated the usefulness of DWI in the detection of liver metastases.

• They compared DWI to unenhanced and dynamic liver specific contrast enhanced MRI.

• Coenegrachts and al showed that lesion conspicuity of hemangiomas and metastases is significantly higher with respiratory triggered DWI at low b-values compared to conventional unenhanced MRI imaging.

• This is due to an excellent lesion to liver contrast and suppression of background signals from vessels.

• Parikh and al reported a significantly higher overall lesion detection rate for breath-hold or respiratory triggered DWI than for conventional T2-weighted MRI (88% vs 70%).

• Bruegel and al compared respiratory DWI-EPI with T2-TSE.

• They found a sensitivity and specificity for T2- TSE MRI of 45%-62% for unenhanced MRI and 88%-91% for DWI-EPI for lesions > 10 mm. When considering only small metastases < 10 mm, the differences between DWI and conventional MRI with and without contrast are even more pronounced: a sensitivity of 85% for DWIEPI and 26%-44% for T2-TSE.

• Lesion detection on T2- TSE is hindered by low lesion to liver contrast and by the interfering bright signal from intrahepatic vessels.
• Lesion conspicuity with DWI is excellent and limitation of the DWI sequence is predominantly referred to lesion characterization rather than to lesion detectability.

Predicting response to therapy of primary and secondary liver malignancies by DWI:

• Tumor responses to chemotherapy and radiation therapy are conventionally assessed by measurement of percentage reduction in tumor size after chemotherapy.

• However, tumor size measurement on CT or MRI is insensitive to early treatment changes.

• Theoretically, DWI is sensitive to micro-environmental changes in tumors that occur after treatment.

• Studies on the predictive value of DWI in primary cancer demonstrated a strong negative correlation between mean pre-treatment ADC values and percentage size reduction of tumors after chemotherapy and chemoradiation.

• High pretreatment ADC values in tumors were associated with a poor response to chemotherapy.

Images for this section:
Fig. 1: Hepatocellular carcinoma. Diffusion weighted image (b-value 600 s/mm²) : the lesion appears hyper-intense.
Fig. 2: Hepatocellular carcinoma. T1 Fatsat weighted image+Gadolinium : Arterial enhancement of the lesion.
Fig. 3: Hepatocellular carcinoma. T1 Fatsat weighted image+Gadolinium: Wash out phenomenon, portal thrombosis.
Fig. 4: Liver metastasis of a lung cancer. In/out phase sequence: The lesion in segment 7 is hypo-intense.
**Fig. 5:** Liver metastasis of a lung cancer. In/out phase sequence: The lesion in segment 7 is hypo-intense.
Fig. 6: Liver metastasis of a lung cancer. T2 weighted image : The lesion is hyper-intense.
Fig. 7: Liver metastasis of a lung cancer. T2 Fatsat weighted image: The lesion is hyperintense.
Fig. 8: Liver metastasis of a lung cancer. Diffusion weighted image (b-value 600 s/mm2) : the lesion appears hyper-intense.
**Fig. 9:** Liver metastases of breast intraductal carcinoma. T2 Fatsat weighted image: The lesions appear hyper-intense.
Fig. 10: Liver metastases of breast intraductal carcinoma. T2 Fatsat weighted image: The lesions appear hyper-intense.
**Fig. 11:** Liver metastases of breast intraductal carcinoma. In/out phase sequence: The lesions appear hypo-intense.
**Fig. 12:** Liver metastases of breast intraductal carcinoma. In/out phase sequence: The lesions appear hypo-intense.
Fig. 13: Liver metastases of breast intraductal carcinoma. Diffusion weighted image (b-value 600 s/mm²): the lesions appear hyper-intense.
**Fig. 14:** Liver metastases of breast intraductal carcinoma. Diffusion weighted image (b-value 600 s/mm²) : the lesions appear hyper-intense.
**Fig. 15:** Liver metastasis of fibrous tumor. T1 Fatsat weighted image: The lesion is hypointense.
**Fig. 16**: Liver metatasis of fibrous tumor. Diffusion weighted image (b-value 600 s/mm2) : the lesions appear hyper-intense.
**Fig. 17:** Hemangioma. T2 Fatsat weighted image: The lesion is hyper-intense.
**Fig. 18:** Hemangioma. In/out phase sequence: The lesion is hypo-intense.
Fig. 19: Hemangioma. In/out phase sequence: The lesion is hypo-intense.
**Fig. 20:** Hemangioma. Diffusion weighted image (b-value 600 s/mm²): No hypersignal corresponding to the lesion was found.
Fig. 21: Hemangioma. T1 Fatsat weighted image without gadolinium.
Fig. 22: Hemangioma. T1 Fatsat weighted image+gadolinium: showed typical enhancement.
Fig. 23: Hemangioma. T1 Fatsat weighted image + gadolinium: showed typical enhancement.
Fig. 24: Hepatoblastoma. T2 weighted image.
Fig. 25: Hepatoblastoma. Diffusion weighted image (b-value 600 s/mm2).
Conclusion

• The present study showed that ADC measurement has the potential to differentiate benign and malignant focal hepatic lesions.

• We propose to add DW sequence in the MR protocol for the detection and quantitative discrimination of hepatic pathologies.

References


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