Diffusion Imaging: Body Applications
Liver Lesions: Added value of Diffusion MRI

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Introduction
The past five years has seen a surge in the utility of diffusion-weighted MRI (DW-MRI) in the body. Amongst the various areas of clinical applications, the evidence for its use appears most compelling for the evaluation of focal liver lesions. Currently, DW-MRI is already in routine use in clinical practice for the evaluation of liver disease. DW-MRI has been used either on its own or in combination with conventional MR imaging techniques for disease detection, disease characterization, evaluation of treatment response, as well as the identification of disease relapse.

Disease detection
When diffusion-weighting is applied to liver, this results in signal suppression from intrahepatic vasculature, thus improving lesion detection. Lesions are seen as focal areas of high signal impeded diffusion on DW-MRI. It has been shown that DW-MRI can achieve a high diagnostic sensitivity for focal lesion detection compared with conventional T2-weighted imaging. However, several studies have shown the value of DW-MRI when used in combination with gadolinium-DTPA or liver selective contrast media (e.g. SPIO, MnDPDP or Gd-EOB-DTPA). For example, using Gd-EOB-DTPA enhanced MR imaging, DW-MRI can help to detect focal lesions that mimic intrahepatic vasculature on the hepatocellular phase of contrast enhanced imaging. On the other hand, hepatocellular phase Gd-EOB-DTPA enhanced imaging appeared better at detecting lesions in areas of the liver prone to artefacts on DW-MRI (e.g. subcardiac or liver periphery). Thus, to achieve the highest diagnostic accuracy, it is advantageous to combine the reading of DW-MRI with contrast enhanced MR imaging.

Disease characterization
DW-MRI should not be used on its own for lesion characterization in the liver. This is because although benign lesions have been found to have significantly higher ADC values compared with benign lesions, there is substantial overlap. Thus, it would be difficult to confidently prospectively classify a lesion as benign or malignant based on the ADC values alone. Even when ADC values are used in clinical practice, it should be remembered that comparison of ADC values should be made when these are derived using similar imaging techniques and b-values. Nevertheless, several studies have reported that an ADC threshold of approximately $1.6 \times 10^{-3}$ mm$^2$/s may achieve a reasonable diagnostic sensitivity and specificity for distinguishing between benign and malignant lesions.

Treatment response
There is emerging evidence that the ADC value may be a useful response and predictive biomarker of tumour response to treatment. Studies have found that ADC values of liver tumours usually increase in responders to chemotherapy, radiotherapy or embolization treatment. Such ADC value increase can be observed as early as one to four weeks following the initiation of treatment, suggesting the potential role of ADC as an early marker of disease response. In addition, studies have also shown that a lower pre-treatment ADC value of tumours may be predictive of a better response to chemotherapy.

Disease relapse
Early experience in using DW-MRI suggests that the technique could be useful for the detection of tumour relapse in the liver following conventional chemotherapy or ablative treatment. These areas show increased impeded diffusion and return low ADC values.